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(54) Title: POLYPEPTIDE-POLYMER CONJUGATES HAVING ADDED AND/OR REMOVED ATTACHMENT GROUPS

## (57) Abstract

The present invention relates to polypeptide-polymer conjugates having added and/or removed one or more attachment groups for coupling polymeric molecules on the surface of the polypeptide structure, a method for preparing polypeptide-polymer conjugates of the invention, the use of said conjugated for reducing the immunogenicity and allergenicity and compositions comprising said conjugate.

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## POLYPEPTIDE-POLYMER CONJUGATES HAVING ADDED AND/OR REMOVED ATTACHMENT GROUPS

## FIELD OF THE INVENTION

The present invention relates to polypeptide-polymer conjugates having added and/or removed one or more attachment groups for coupling polymeric molecules on the surface of the 3D structure of the polypeptide, a method for preparing polypeptide-polymer conjugates of the invention, the use of said conjugated for reducing the immunogenicity and allergenicity, and compositions comprising said conjugate.

## BACKGROUND OF THE INVENTION

The use of polypeptides, including enzymes, in the circulatory system to obtain a particular physiological effect is well-known in the medical arts. Further, within the arts of industrial applications, such as laundry washing, textile bleaching, person care, contact lens cleaning, food and feed preparation enzymes are used as a functional ingredient. One of the important differences between pharmaceutical and industrial application is that for the latter type of applications (i.e. industrial applications) the polypeptides (often enzymes) are not intended to enter into the circulatory system of the body.

Certain polypeptides and enzymes have an unsatisfactory stability and may under certain circumstances - dependent on the way of challenge - cause an immune response, typically an IgG and/or IgE response.

It is today generally recognized that the stability of polypeptides is improved and the immune response is reduced when polypeptides, such as enzymes, are coupled to polymeric molecules. It is believed that the reduced immune response is a result of the shielding of (the) epitope(s) on the surface of the polypeptide responsible for the immune response leading to antibody formation by the coupled polymeric molecules.

Techniques for conjugating polymeric molecules to polypeptides are well-known in the art.

One of the first suitable commercially techniques was described back in the early 1970'ies and disclosed in e.g. US patent no. 4,179,337. Said patent concerns non-immunogenic polypeptides, such

as enzymes and peptide hormones coupled to polyethylene glycol (PEG) or polypropylene glycol (PPG). At least 15% of polypeptides' physiological activity is maintained.

GB patent no. 1,183,257 (Crook et al.) describes chemistry for 5 conjugation of enzymes to polysaccharides via a triazine ring.

Further, techniques for maintaining of the enzymatic activity of enzyme-polymer conjugates are also known in the art.

WO 93/15189 (Veronese et al.) concerns a method for maintaining the activity in polyethylene glycol-modified proteolytic enzymes 10 by linking the proteolytic enzyme to a macromolecularized inhibitor. The conjugates are intended for medical applications.

It has been found that the attachment of polymeric molecules to a polypeptide often has the effect of reducing the activity of the polypeptide by interfering with the interaction between the 15 polypeptide and its substrate. EP 183 503 (Beecham Group PLC) discloses a development of the above concept by providing conjugates comprising pharmaceutically useful proteins linked to at least one water-soluble polymer by means of a reversible linking group.

20 EP 471,125 (Kanebo) discloses skin care products comprising a parent protease (*Bacillus* protease with the trade name Esperase®) coupled to polysaccharides through a triazine ring to improve the thermal and preservation stability. The coupling technique used is also described in the above mentioned GB patent no. 1,183,257 25 (Crook et al.).

JP 3083908 describes a skin cosmetic material which contains a transglutaminase from guinea pig liver modified with one or more water-soluble substance such as PEG, starch, cellulose etc. The modification is performed by activating the 30 polymeric molecules and coupling them to the enzyme. The composition is stated to be mild to the skin.

However, it is not always possible to readily couple polymeric molecules to polypeptides and enzymes. Further, there is still a need for polypeptide-polymer conjugates with an even more 35 reduced immunogenicity and/or allergenicity.

#### SUMMARY OF THE INVENTION

It is the object of the present invention to provide improved

polypeptide-polymer conjugates suitable for industrial and pharmaceutical applications.

The term "improved polypeptide-polymer conjugates" means in the context of the present invention conjugates having a reduced 5 immune response in humans and animals and/or a improved stability. As will be described further below the immune response is dependent on the way of challenge.

The present inventors have found that polypeptides, such as enzymes, may be made less immunogenic and/or allergenic by adding 10 and/or removing one or more attachment groups on the surface of the parent polypeptide to be coupled to polymeric molecules.

When introducing pharmaceutical polypeptide directly into the circulatory system (i.e. bloodstream) the potential risk is an immunogenic response in the form of mainly IgG, IgA and/or IgM 15 antibodies. In contrast hereto, industrial polypeptides, such as enzymes used as a functional ingredient in e.g. detergents, are not intended to enter the circulatory system. The potential risk in connection with industrial polypeptides is inhalation causing an allergenic response in the form of mainly IgE antibody 20 formation.

Therefore, in connection with industrial polypeptides the potential risk is respiratory allergenicity caused by inhalation, intratracheal and intranasal presentation of polypeptides.

The main potential risk of pharmaceutical polypeptides is 25 immunogenicity caused by intradermally, intravenously or subcutaneously presentation of the polypeptide.

It is to be understood that reducing the "immunogenicity" and reducing the "respiratory allergenicity" are two very different problems based on different routes of exposure and on 30 two very different immunological mechanisms:

The term "immunogenicity" used in connection with the present invention may be referred to as allergic contact dermatitis in a clinical setting and is a cell mediated delayed immune response to chemicals that contact and penetrate the skin. 35 This cell mediated reaction is also termed delayed contact hypersensitivity (type IV reaction according to Gell and Combs classification of immune mechanisms in tissue damage).

The term "allergenicity" or "respiratory allergenicity" is an

immediate anaphylactic reaction (type I antibody-mediated reaction according to Gell and Combs) following inhalation of e.g. polypeptides.

According to the present invention it is possible to provide 5 polypeptides with a reduced immune response and/or improved stability, which has a substantially retained residual activity.

The allergic and the immunogenic response are in one term, at least in the context of the present invention called the "immune response".

10 In the first aspect the invention relates to a polypeptide-polymer conjugate having

- a) one or more additional polymeric molecules coupled to the polypeptide having been modified in a manner to increase the number of attachment groups on the surface of the polypeptide in 15 comparison to the number of attachment groups available on the corresponding parent polypeptide, and/or
- b) one or more fewer polymeric molecules coupled to the polypeptide having been modified in a manner to decrease the number of attachment groups at or close to the functional site(s) 20 of the polypeptide in comparison to the number of attachment groups available on the corresponding parent polypeptide.

The term "parent polypeptide" refers to the polypeptide to be modified by coupling to polymeric molecules. The parent polypeptide may be a naturally-occurring (or wild-type) 25 polypeptide or may be a variant thereof prepared by any suitable means. For instance, the parent polypeptide may be a variant of a naturally-occurring polypeptide which has been modified by substitution, deletion or truncation of one or more amino acid residues or by addition or insertion of one or more amino acid 30 residues to the amino acid sequence of a naturally-occurring polypeptide.

A "suitable attachment group" means in the context of the present invention any amino acid residue group on the surface of the polypeptide capable of coupling to the polymeric molecule in 35 question.

Preferred attachment groups are amino groups of Lysine residues and the N-terminal amino group. Polymeric molecules may also be coupled to the carboxylic acid groups (-COOH) of amino

acid residues in the polypeptide chain located on the surface. Carboxylic acid attachment groups may be the carboxylic acid group of Aspartate or Glutamate and the C-terminal COOH-group.

A "functional site" means any amino acid residues and/or cofactors which are known to be essential for the performance of the polypeptide, such as catalytic activity, e.g. the catalytic triad residues, Histidine, Aspartate and Serine in Serine proteases, or e.g. the heme group and the distal and proximal Histidines in a peroxidase such as the *Arthromyces ramosus* peroxidase.

In the second aspect the invention relates to a method for preparing improved polypeptide-polymer conjugates comprising the steps of:

- a) identifying amino acid residues located on the surface of the 15 3D structure of the parent polypeptide in question,
- b) selecting target amino acid residues on the surface of said 3D structure of said parent polypeptide to be mutated,
- c) i) substituting or inserting one or more amino acid residues selected in step b) with an amino acid residue having a 20 suitable attachment group, and/or
  - ii) substituting or deleting one or more amino acid residues selected in step b) at or close to the functional site(s),
- d) coupling polymeric molecules to the mutated polypeptide.

The invention also relates to the use of a conjugate of the 25 invention and the method of the invention for reducing the immunogenicity of pharmaceuticals and reducing the allergenicity of industrial products.

Finally the invention relates to compositions comprising a conjugate of the invention and further ingredients used in 30 industrial products or pharmaceuticals.

#### **BRIEF DESCRIPTION OF THE DRAWING**

Figure 1 shows the anti-lipase serum antibody levels after 5 weekly immunizations with i) control ii) unmodified lipase 35 variant, iii) lipase variant-SPEG. (X: log(serum dilution); Y Optical Density (490/620)).

#### **DETAILED DESCRIPTION OF THE INVENTION**

It is the object of the present invention to provide improved polypeptide-polymer conjugates suitable for industrial and pharmaceutical applications.

Even though polypeptides used for pharmaceutical applications 5 and industrial application can be quite different the principle of the present invention may be tailored to the specific type of parent polypeptide (i.e. enzyme, hormone peptides etc.).

The inventors of the present invention have provided improved polypeptide-polymer conjugates with a reduced immune response in 10 comparison to conjugates prepared from the corresponding parent polypeptides.

The present inventors have found that polypeptides, such as enzymes, may be made less immunogenic and/or less allergenic by adding one or more attachment groups on the surface of the parent 15 polypeptide. In addition thereto the inventors have found that a higher percentage of maintained residual functional activity may be obtained by removing attachment groups at or close to the functional site(s).

In the first aspect the invention relates to an improved 20 polypeptide-polymer conjugate having

a) one or more additional polymeric molecules coupled to the polypeptide having been modified in a manner to increase the number of attachment groups on the surface of the polypeptide in comparison to the number of attachment groups available on the 25 corresponding parent polypeptide, and/or

b) one or more fewer polymeric molecules coupled to the polypeptide having been modified in a manner to decrease the number of attachment groups at or close to the functional site(s) of the polypeptide in comparison to the number of attachment 30 groups available on the corresponding parent polypeptide.

Whether the attachment groups should be added and/or removed depends on the specific parent polypeptide.

a) Addition of Attachment groups

35 There may be a need for further attachment groups on the polypeptide if only few attachment groups are available on the surface of the parent polypeptide. The addition of one or more attachment groups by substituting or inserting one or more amino

acid residues on the surface of the parent polypeptide increases the number of polymeric molecules which may be attached in comparison to the corresponding parent polypeptide. Conjugates with an increased number of polymeric molecules attached thereto 5 are generally seen to have a reduced immune response in comparison to the corresponding conjugates having fewer polymeric molecules coupled thereto.

Any available amino acid residues on the surface of the polypeptide, preferentially not being at or close to the 10 functional site(s), such as the active site(s) of enzymes, may in principle be subject to substitution and/or insertion to provide additional attachment groups.

As will be described further below the location of the additional coupled polymeric molecules may be of importance for 15 the reduction of the immune response and the percentage of maintained residual functional activity of the polypeptide itself.

A conjugate of the invention may typically have from 1 to 25, preferentially 1 to 10 or more additional polymeric molecules coupled to the surface of the polypeptide in comparison to the 20 number of polymeric molecules of a conjugate prepared on the basis of the corresponding parent polypeptide.

However, the optimal number of attachment group to be added depends (at least partly) on the surface area (i.e. molecular weight) of the parent polypeptide to be shielded by the coupled 25 polymeric molecules, and further off-course also the number of already available attachment groups on the parent polypeptide.

#### b) Removing Attachment groups

In the case of enzymes or other polypeptides performing their 30 function by interaction with a substrate or the like, polymeric molecules coupled to the polypeptide might be impeded by the interaction between the polypeptide and its substrate or the like, if they are coupled at or close to the functional site(s) (i.e. active site of enzymes). This will most probably cause reduced 35 activity.

In the case of enzymes having one or more polymeric molecules coupled at or close to the active site a substantial loss of residual enzymatic activity can be expected. Therefore, according

to the invention conjugates may be constructed to maintain a higher percentage of residual enzymatic activity in comparison to a corresponding conjugates prepared on the basis of the parent enzyme in question. This may be done by substituting and/or 5 deleting attachment groups at or close to the active site, hereby increasing the substrate affinity by improving the accessibility of the substrate in the catalytic cleft.

An enzyme-polymer conjugate of the invention may typically have from 1 to 25, preferably 1 to 10 fewer polymeric molecules coupled 10 at or close to the active site in comparison to the number of polymeric molecules of a conjugate prepared on the basis of the corresponding parent polypeptide.

As will be explained below "at or close to" the functional site(s) means that no polymeric molecule(s) should be coupled 15 within 5 Å, preferably 8 Å, especially 10 Å of the functional site(s).

Removal of attachment groups at or close to the functional site(s) of the polypeptide may advantageously be combined with addition of attachment groups in other parts of the surface of the 20 polypeptide.

The total number of attachment groups may this way be unchanged, increased or decreased. However the location(s) of the total number of attachment group(s) is(are) improved assessed by the reduction of the immune response and/or percentage of 25 maintained residual activity. Improved stability may also be obtained this way.

#### The number of attachment groups

Generally seen the number of attachment groups should be 30 balanced to the molecular weight and/or surface area of the polypeptide. The more heavy the polypeptide is the more polymeric molecules should be coupled to the polypeptide to obtain sufficient shielding of the epitope(s) responsible for antibody formation.

35 Therefore, if the parent polypeptide molecule is relatively light (e.g. 1 to 35 kDa) it may be advantageous to increase the total number of coupled polymeric molecules (outside the functional site(s)) to a total between 4 and 20.

If the parent polypeptide molecules is heavier, for instance 35 to 60 kDa, the number of coupled polymeric molecules (outside the functional site(s)) may advantageously be increased to 7 to 40, and so on.

5 The ratio between the molecular weight ( $M_w$ ) of the polypeptide in question and the number of coupled polymeric molecules considered to be suitable by the inventors is listed below in Table 1.

10 Table 1

Molecular weight of parent polypeptide ( $M_w$ ) kDa	Number of polymeric molecules coupled to the polypeptide
1 to 35	4-20
35 to 60	7-40
60 to 80	10-50
80 to 100	15-70
more than 100	more than 20

Reduced immune response vs. maintained residual enzymatic activity

Especially for enzymes, in comparison to many other types of polypeptides, there is a conflict between reducing the immune 15 response and maintaining a substantial residual enzymatic activity as the activity of enzymes are connected with interaction between a substrate and the active site often present as a cleft in the enzyme structure.

Without being limited to any theory it is believed that the 20 loss of enzymatic activity of enzyme-polymer conjugates might be a consequence of impeded access of the substrate to the active site in the form of spatial hindrance of the substrate by especially bulky and/or heavy polymeric molecules to the catalytic cleft. It might also, at least partly, be caused by disadvantageous minor 25 structural changes of the 3D structure of the enzyme due to the stress made by the coupling of the polymeric molecules.

Maintained residual activity

A polypeptide-polymer conjugates of the invention has a 30 substantially maintained functional activity.

A "substantially" maintained functional activity is in the context of the present invention defined as an activity which is at least between 20% and 30%, preferably between 30% and 40%, more preferably between 40% and 60%, better from 60% up to 80%, even 5 better from 80% up to about 100%, in comparison to the activity of the conjugates prepared on the basis of corresponding parent polypeptides.

In the case of polypeptide-polymer conjugates of the invention where no polymeric molecules are coupled at or close to 10 the functional site(s) the residual activity may even be up to 100% or very close thereto. If attachment group(s) of the parent polypeptide is(are) removed from the functional site the activity might even be more than 100% in comparison to modified (i.e. polymer coupled) parent polypeptide conjugate.

15 Position of coupled polymeric molecules

To obtain an optimally reduced immune response (i.e. immunogenic and allergenic response) the polymeric molecules coupled to the surface of the polypeptide in question should be located in a suitable distance from each other.

20 In a preferred embodiment of the invention the parent polypeptide is modified in a manner whereby the polymeric molecules are spread broadly over the surface of the polypeptide. In the case of the polypeptide in question has enzymatic activity it is preferred to have as few as possible, especially none, 25 polymeric molecules coupled at or close to the area of the active site.

In the present context "spread broadly over the surface of the polypeptide" means that the available attachment groups are located so that the polymeric molecules shield different parts of 30 the surface, preferable the whole or close to the whole surface area away from the functional site(s), to make sure that epitope(s) are shielded and hereby not recognized by the immune system or its antibodies.

The area of antibody-polypeptide interaction typically 35 covers an area of 500 Å<sup>2</sup>, as described by Sheriff et al. (1987), Proc. Natl. Acad. Sci. USA 84, p. 8075-8079. 500 Å<sup>2</sup> corresponds to a rectangular box of 25 Å x 20 Å or a circular region of radius 12.6 Å. Therefore, to prevent binding of

antibodies to the epitope(s) to the polypeptide in question it is preferred to have a maximum distance between two attachment groups around 10 Å.

Consequently, amino acid residues which are located in excess 5 of 10 Å away from already available attachment groups are suitable target residues. If two or more attachment groups on the polypeptide are located very close to each other it will in most cases result in that only one polymeric molecule will be coupled.

To ensure a minimal loss of functional activity it is preferred 10 not to couple polymeric molecules at or close to the functional site(s). Said distance depends at least partly on the bulkiness of the polymeric molecules to be coupled, as impeded access by the bulky polymeric molecules to the functional site is undesired.

Therefore, the more bulky the polymeric molecules are the longer 15 should the distance from the functional site to the coupled polymeric molecules be.

To maintain a substantial functional activity of the polypeptide in question attachment groups located within 5 Å, preferred 8 Å, especially 10 Å from such functional site(s) 20 should be left uncoupled and may therefore advantageously be removed or changed by mutation. Functional residues should normally not be mutated/removed, even though they potentially can be the target for coupling polymeric molecules. In said case it may thus be advantageous to chose a coupling chemistry 25 involving different attachment groups.

Further, to provide a polypeptide having coupled polymeric molecules at (a) known epitope(s) recognizable by the immune system or close to said epitope(s) specific mutations at such sites are also considered advantageous according to the invention. 30 If the position of the epitope(s) is(are) unknown it is advantageous to couple several or many polymeric molecules to the polypeptide.

As also mentioned above it is preferred that said attachment groups are spread broadly over the surface.

35

#### The attachment group

Virtually all ionized groups, such as the amino groups of Lysine residues, are located on the surface of the polypeptide

molecule (see for instance Thomas E. Creighton, (1993), "Proteins", W.H. Freeman and Company, New York).

Therefore, the number of readily accessible attachment groups (e.g. amino groups) on a modified or parent polypeptide equals 5 generally seen the number of Lysine residues in the primary structure of the polypeptide plus the N-terminus amino group.

The chemistry of coupling polymeric molecules to amino groups are quite simple and well established in the art. Therefore, it is preferred to add and/or remove Lysine residues (i.e. attachment 10 groups) to/from the parent polypeptide in question to obtain improved conjugates with reduced immunogenicity and/or allergenicity and/or improved stability and/or high percentage maintained functional activity.

Polymeric molecules may also be coupled to the carboxylic 15 groups (-COOH) of amino acid residues on the surface of the polypeptide. Therefore, if using carboxylic groups (including the C-terminal group) as attachment groups addition and/or removal of Aspartate and Glutamate residues may also be a suitable according to the invention.

20 If using other attachment groups, such as -SH groups, they may be added and/or removed analogously.

Substitution of the amino acid residues is preferred over insertion, as the impact on the 3D structure of the polypeptide normally will be less pronounced.

25 Preferred substitutions are conservative substitutions. In the case of increasing the number of attachment groups the substitution may advantageously be performed at a location having a distance of 5 Å, preferred 8 Å, especially 10 Å from the functional site(s) (active site for enzymes).

30 An example of a suitable conservative substitution to obtain an additional amino attachment group is a Arginine to Lysine substitution. Examples of conservative substitutions to obtain additional carboxylic attachment groups are Aspargine to Aspartate/Glutamate or Glutamine to Aspartate/Glutamate 35 substitutions. To remove attachment groups a Lysine residue may be substituted with a Arginine and so on.

The parent polypeptide

In the context of the present invention the term "polypeptides" includes proteins, peptides and/or enzymes for pharmaceutical or industrial applications. Typically the polypeptides in question have a molecular weight in the range between about 1 to 100 kDa, 5 often 15 kDa and 100 kDa.

#### Pharmaceutical polypeptides

The term "pharmaceutical polypeptides" is defined as polypeptides, including peptides, such as peptide hormones, proteins 10 and/or enzymes, being physiologically active when introduced into the circulatory system of the body of humans and/or animals.

Pharmaceutical polypeptides are potentially immunogenic as they are introduced into the circulatory system.

Examples of "pharmaceutical polypeptides" contemplated 15 according to the invention include insulin, ACTH, glucagon, somatostatin, somatotropin, thymosin, parathyroid hormone, pigmentary hormones, somatomedin, erythropoietin, luteinizing hormone, chorionic gonadotropin, hypothalamic releasing factors, antidiuretic hormones, thyroid stimulating hormone, relaxin, 20 interferon, thrombopoietin (TPO) and prolactin.

#### Industrial polypeptides

Polypeptides used for industrial applications often have an enzymatic activity. Industrial polypeptides (e.g. enzymes) are (in 25 contrast to pharmaceutical polypeptides) not intended to be introduced into the circulatory system of the body.

It is not very likely that industrial polypeptides, such as enzymes used as ingredients in industrial compositions and/or products, such as detergents and personal care products, including 30 cosmetics, come into direct contact with the circulatory system of the body of humans or animals, as such enzymes (or products comprising such enzymes) are not injected (or the like) into the bloodstream.

Therefore, in the case of the industrial polypeptide the 35 potential risk is respiratory allergy (i.e. IgE response) as a consequence of inhalation to polypeptides through the respiratory passage.

In the context of the present invention "industrial polypep-

tides" are defined as polypeptides, including peptides, proteins and/or enzymes, which are not intended to be introduced into the circulatory system of the body of humans and/or animals.

Examples of such polypeptides are polypeptides, especially 5 enzymes, used in products such as detergents, household article products, agrochemicals, personal care products, such as skin care products, including cosmetics and toiletries, oral and dermal pharmaceuticals, composition use for processing textiles, compositions for hard surface cleaning, and compositions used for 10 manufacturing food and feed etc.

#### Enzymatic activity

Pharmaceutical or industrial polypeptides exhibiting enzymatic activity will often belong to one of the following groups of 15 enzymes including Oxidoreductases (E.C. 1, "Enzyme Nomenclature, (1992), Academic Press, Inc.), such as laccase and Superoxide dismutase (SOD); Transferases, (E.C. 2), such as transglutaminases (TGases); Hydrolases (E.C. 3), including proteases, especially subtilisins, and lipolytic enzymes; Isomerases (E.C. 5), such as 20 Protein disulfide Isomerases (PDI).

#### Hydrolases

##### Proteolytic enzymes

Contemplated proteolytic enzymes include proteases selected 25 from the group of Aspartic proteases, such pepsins, Cysteine proteases, such as Papain, Serine proteases, such as subtilisins, or metallo proteases, such as Neutrase®.

Specific examples of parent proteases include PD498 (WO 93/24623 and SEQ ID NO. 2), Savinase® (von der Osten et al., 30 (1993), Journal of Biotechnology, 28, p. 55+, SEQ ID NO 3), Proteinase K (Gunkel et al., (1989), Eur. J. Biochem, 179, p. 185-194), Proteinase R (Samal et al., (1990), Mol. Microbiol, 4, p. 1789-1792), Proteinase T (Samal et al., (1989), Gene, 85, p. 329-333), Subtilisin DY (Betzel et al. (1993), Arch. Biophys, 302, no. 35 2, p. 499-502), Lion Y (JP 04197182-A), Rennilase® (Available from Novo Nordisk A/S), JA16 (WO 92/17576), Alcalase® (a natural subtilisin Carlberg variant) (von der Osten et al., (1993), Journal of Biotechnology, 28, p. 55+).

**Lipolytic enzymes**

Contemplated lipolytic enzymes include *Humicola lanuginosa* lipases, e.g. the one described in EP 258 068 and EP 305 216 (See 5 SEQ ID NO 6 below), *Humicola insolens*, a *Rhizomucor miehei* lipase, e.g. as described in EP 238 023, *Absidia* sp. lipolytic enzymes (WO 96/13578), a *Candida* lipase, such as a *C. antarctica* lipase, e.g. the *C. antarctica* lipase A or B described in EP 214 761, a *Pseudomonas* lipase such as a *P. alcaligenes* and *P. 10 pseudoalcaligenes* lipase, e.g. as described in EP 218 272, a *P. cepacia* lipase, e.g. as described in EP 331 376, a *Pseudomonas* sp. lipase as disclosed in WO 95/14783, a *Bacillus* lipase, e.g. a *B. subtilis* lipase (Dartois et al., (1993) *Biochemica et Biophysica acta* 1131, 253-260), a *B. stearothermophilus* lipase (JP 64/744992) 15 and a *B. pumilus* lipase (WO 91/16422). Other types of lipolytic include cutinases, e.g. derived from *Pseudomonas mendocina* as described in WO 88/09367, or a cutinase derived from *Fusarium solani pisi* (e.g. described in WO 90/09446).

**20 Oxidoreductases****Laccases**

Contemplated laccases include *Polyporus pinisitus* laccase (WO 96/00290), *Myceliophthora* laccase (WO 95/33836), *Schytalidium* laccase (WO 95/338337), and *Pyricularia oryzae* laccase (Available 25 from Sigma).

**Peroxidase**

Contemplated peroxidases include *B. pumilus* peroxidases (WO 91/05858), *Myxococcaceae* peroxidase (WO 95/11964), *Coprinus* 30 *cinereus* (WO 95/10602) and *Arthromyces ramosus* peroxidase (Kunishima et al. (1994), *J. Mol. Biol.* 235, p. 331-344).

**Transferases****Transglutaminases**

35 Suitable transferases include any transglutaminases disclosed in WO 96/06931 (Novo Nordisk A/S) and WO 96/22366 (Novo Nordisk A/S).

**Isomerases****Protein Disulfide Isomerase**

Without being limited thereto suitable protein disulfide isomerases include PDIs described in WO 95/01425 (Novo Nordisk 5 A/S).

**The polymeric molecule**

The polymeric molecules coupled to the polypeptide may be any suitable polymeric molecule, including natural and synthetic homopolymers, such as polyols (i.e. poly-OH), polyamines (i.e. poly-NH<sub>2</sub>) and polycarboxyl acids (i.e. poly-COOH), and further heteropolymers i.e. polymers comprising one or more different coupling groups e.g. a hydroxyl group and amine groups.

Examples of suitable polymeric molecules include polymeric molecules selected from the group comprising polyalkylene oxides (PAO), such as polyalkylene glycols (PAG), including polyethylene glycols (PEG), methoxypolyethylene glycols (mPEG) and polypropylene glycols, PEG-glycidyl ethers (Epox-PEG), PEG-oxycarbonylimidazole (CDI-PEG), Branced PEGs, poly-vinyl alcohol (PVA), poly-carboxylates, poly-(vinylpyrrolidone), poly-D,L-amino acids, polyethylene-co-maleic acid anhydride, polystyrene-co-malic acid anhydrid, dextrans including carboxymethyl-dextrans, heparin, homologous albumin, celluloses, including methylcellulose, carboxymethylcellulose, ethylcellulose, hydroxyethylcellulose, carboxyethylcellulose and hydroxypropylcellulose, hydrolysates of chitosan, starches such as hydroxyethyl-straches and hydroxy propyl-starches, glycogen, agaroses and derivates thereof, guar gum, pullulan, inulin, xanthan gum, carrageenin, pectin, alginic acid hydrolysates and bio-polymers.

Preferred polymeric molecules are non-toxic polymeric molecules such as (m)polyethylene glycol ((m)PEG) which further requires a relatively simple chemistry for its covalently coupling to attachment groups on the enzyme's surface.

Generally seen polyalkylene oxides (PAO), such as polyethylene oxides, such as PEG and especially mPEG, are the preferred polymeric molecules, as these polymeric molecules, in comparison to polysaccharides such as dextran, pullulan and the like, have few reactive groups capable of cross-linking.

Even though all of the above mentioned polymeric molecules may be used according to the invention the methoxypolyethylene glycols (mPEG) may advantageously be used. This arise from the fact that methoxyethylene glycols have only one reactive end capable of 5 conjugating with the enzyme. Consequently, the risk of cross-linking is less pronounced. Further, it makes the product more homogeneous and the reaction of the polymeric molecules with the enzyme easier to control.

#### 10 Preparation of enzyme variants

Enzyme variants to be conjugated may be constructed by any suitable method. A number of methods are well established in the art. For instance enzyme variants according to the invention may be generated using the same materials and methods 15 described in e.g. WO 89/06279 (Novo Nordisk A/S), EP 130,756 (Genentech), EP 479,870 (Novo Nordisk A/S), EP 214,435 (Henkel), WO 87/04461 (Amgen), WO 87/05050 (Genex), EP application no. 87303761 (Genentech), EP 260,105 (Genencor), WO 88/06624 (Gist-Brocades NV), WO 88/07578 (Genentech), WO 20 88/08028 (Genex), WO 88/08033 (Amgen), WO 88/08164 (Genex), Thomas et al. (1985) *Nature*, 318 375-376; Thomas et al. (1987) *J. Mol. Biol.*, 193, 803-813; Russel and Fersht (1987) *Nature* 328 496-500.

#### 25 Generation of site directed mutations

Prior to mutagenesis the gene encoding the polypeptide of interest must be cloned in a suitable vector. Methods for generating mutations in specific sites is described below.

Once the polypeptide encoding gene has been cloned, and 30 desirable sites for mutation identified and the residue to substitute for the original ones have been decided, these mutations can be introduced using synthetic oligonucleotides. These oligonucleotides contain nucleotide sequences flanking the desired mutation sites; mutant nucleotides are inserted during 35 oligo-nucleotide synthesis. In a preferred method, Site-directed mutagenesis is carried out by SOE-PCR mutagenesis technique described by Kammann et al. (1989) *Nucleic Acids Research* 17(13), 5404, and by Sarkar G. and Sommer, S.S. (1990); *Biotechniques* 8,

404-407.

Activation of polymers

If the polymeric molecules to be conjugated with the 5 polypeptide in question are not active it must be activated by the use of a suitable technique. It is also contemplated according to the invention to couple the polymeric molecules to the polypeptide through a linker. Suitable linkers are well-known to the skilled person.

10 Methods and chemistry for activation of polymeric molecules as well as for conjugation of polypeptides are intensively described in the literature. Commonly used methods for activation of insoluble polymers include activation of functional groups with cyanogen bromide, periodate, glutaraldehyde, biepoxides, 15 epichlorohydrin, divinylsulfone, carbodiimide, sulfonyl halides, trichlorotriazine etc. (see R.F. Taylor, (1991), "Protein immobilisation. Fundamental and applications", Marcel Dekker, N.Y.; S.S. Wong, (1992), "Chemistry of Protein Conjugation and Crosslinking", CRC Press, Boca Raton; G.T. Hermanson et al., 20 (1993), "Immobilized Affinity Ligand Techniques", Academic Press, N.Y.). Some of the methods concern activation of insoluble polymers but are also applicable to activation of soluble polymers e.g. periodate, trichlorotriazine, sulfonylhalides, 25 divinylsulfone, carbodiimide etc. The functional groups being amino, hydroxyl, thiol, carboxyl, aldehyde or sulphydryl on the polymer and the chosen attachment group on the protein must be considered in choosing the activation and conjugation chemistry which normally consist of i) activation of polymer, ii) conjugation, and iii) blocking of residual active groups.

30 In the following a number of suitable polymer activation methods will be described shortly. However, it is to be understood that also other methods may be used.

Coupling polymeric molecules to the free acid groups of polypeptides may be performed with the aid of diimide and for example 35 amino-PEG or hydrazino-PEG (Pollak et al., (1976), J. Amr. Chem. Soc., 98, 289-291) or diazoacetate/amide (Wong et al., (1992), "Chemistry of Protein Conjugation and Crosslinking", CRC Press).

Coupling polymeric molecules to hydroxy groups are generally

very difficult as it must be performed in water. Usually hydrolysis predominates over reaction with hydroxyl groups.

Coupling polymeric molecules to free sulfhydryl groups can be reached with special groups like maleimido or the *ortho*-pyridyl 5 disulfide. Also vinylsulfone (US patent no. 5,414,135, (1995), Snow et al.) has a preference for sulfhydryl groups but is not as selective as the other mentioned.

Accessible Arginine residues in the polypeptide chain may be targeted by groups comprising two vicinal carbonyl groups.

10 Techniques involving coupling electrophilically activated PEGs to the amino groups of Lysines may also be useful. Many of the usual leaving groups for alcohols give rise to an amine linkage. For instance, alkyl sulfonates, such as tresylates (Nilsson et al., (1984), Methods in Enzymology vol. 104, Jacoby, 15 W. B., Ed., Academic Press: Orlando, p. 56-66; Nilsson et al., (1987), Methods in Enzymology vol. 135; Mosbach, K., Ed.; Academic Press: Orlando, pp. 65-79; Scouten et al., (1987), Methods in Enzymology vol. 135, Mosbach, K., Ed., Academic Press: Orlando, 1987; pp 79-84; Crossland et al., (1971), J. Amr. Chem. Soc. 1971, 20 93, pp. 4217-4219), mesylates (Harris, (1985), supra; Harris et al., (1984), J. Polym. Sci. Polym. Chem. Ed. 22, pp 341-352), aryl sulfonates like tosylates, and para-nitrobenzene sulfonates can be used.

Organic sulfonyl chlorides, e.g. Tresyl chloride, effectively 25 converts hydroxy groups in a number of polymers, e.g. PEG, into good leaving groups (sulfonates) that, when reacted with nucleophiles like amino groups in polypeptides allow stable linkages to be formed between polymer and polypeptide. In addition to high conjugation yields, the reaction conditions are in general mild 30 (neutral or slightly alkaline pH, to avoid denaturation and little or no disruption of activity), and satisfy the non-destructive requirements to the polypeptide.

Tosylate is more reactive than the mesylate but also more unstable decomposing into PEG, dioxane, and sulfonic acid (Zalipsky, 35 (1995), Bioconjugate Chem., 6, 150-165). Epoxides may also be used for creating amine bonds but are much less reactive than the above mentioned groups.

Converting PEG into a chloroformate with phosgene gives rise

to carbamate linkages to Lysines. This theme can be played in many variants substituting the chlorine with N-hydroxy succinimide (US patent no. 5,122,614, (1992); Zalipsky et al., (1992), Biotechnol. Appl. Biochem., 15, p. 100-114; Monfardini et al., (1995), Bioconjugate Chem., 6, 62-69, with imidazole (Allen et al., (1991), Carbohydr. Res., 213, pp 309-319), with para-nitrophenol, DMAP (EP 632 082 A1, (1993), Looze, Y.) etc. The derivatives are usually made by reacting the chloroformate with the desired leaving group. All these groups give rise to carbamate linkages to the peptide.

10 Furthermore, isocyanates and isothiocyanates may be employed yielding ureas and thioureas, respectively.

Amides may be obtained from PEG acids using the same leaving groups as mentioned above and cyclic imid thrones (US patent no. 5,349,001, (1994), Greenwald et al.). The reactivity of these compounds are very high but may make the hydrolysis to fast.

15 PEG succinate made from reaction with succinic anhydride can also be used. The hereby comprised ester group make the conjugate much more susceptible to hydrolysis (US patent no. 5,122,614, (1992), Zalipsky). This group may be activated with N-hydroxy succinimide.

20 Furthermore, a special linker can be introduced. The oldest being cyanuric chloride (Abuchowski et al., (1977), J. Biol. Chem., 252, 3578-3581; US patent no. 4,179,337, (1979), Davis et al.; Shafer et al., (1986), J. Polym. Sci. Polym. Chem. Ed., 24, 375-378.

25 Coupling of PEG to an aromatic amine followed by diazotation yields a very reactive diazonium salt which *in situ* can be reacted with a peptide. An amide linkage may also be obtained by reacting an azlactone derivative of PEG (US patent no. 5,321,095, (1994), Greenwald, R. B.) thus introducing an additional amide linkage.

As some peptides do not comprise many Lysines it may be advantageous to attach more than one PEG to the same Lysine. This can be done e.g. by the use of 1,3-diamino-2-propanol.

30 PEGs may also be attached to the amino-groups of the enzyme with carbamate linkages (WO 95/11924, Greenwald et al.). Lysine residues may also be used as the backbone.

The coupling technique used in the examples is the N-succinimidyl carbonate conjugation technique described in WO

90/13590 (Enzon).

Method for preparing improved conjugates

It is also an object of the invention to provide a method for 5 preparing improved polypeptide-polymer conjugates comprising the steps of:

- a) identifying amino acid residues located on the surface of the 3D structure of the parent polypeptide in question,
- b) selecting target amino acid residues on the surface of said 3D 10 structure of said parent polypeptide to be mutated,
- c) i) substituting or inserting one or more amino acid residues selected in step b) with an amino acid residue having a suitable attachment group, and/or
- ii) substituting or deleting one or more amino acid residues 15 selected in step b) at or close to the functional site(s),
- d) coupling polymeric molecules to the mutated polypeptide.

Step a) Identifying amino acid residues located on the surface of the parent polypeptide

20

3-dimensional structure (3D-structure)

To perform the method of the invention a 3-dimensional structure of the parent polypeptide in question is required. This structure may for example be an X-ray structure, an NMR 25 structure or a model-built structure. The Brookhaven Databank is a source of X-ray- and NMR-structures.

A model-built structure may be produced by the person skilled in the art if one or more 3D-structure(s) exist(s) of homologous polypeptide(s) sharing at least 30% sequence 30 identity with the polypeptide in question. Several software packages exist which may be employed to construct a model structure. One example is the Homology 95.0 package from Biosym.

Typical actions required for the construction of a model 35 structure are: alignment of homologous sequences for which 3D-structures exist, definition of Structurally Conserved Regions (SCRs), assignment of coordinates to SCRs, search for structural fragments/loops in structure databases to replace

Variable Regions, assignment of coordinates to these regions, and structural refinement by energy minimization. Regions containing large inserts ( $\geq 3$  residues) relative to the known 5 3D-structures are known to be quite difficult to model, and structural predictions must be considered with care.

Having obtained the 3D-structure of the polypeptide in question, or a model of the structure based on homology to known structures, this structure serves as an essential prerequisite for the fulfillment of the method described below.

10

Step b) Selection of target amino acid residues for mutation

Target amino acid residues to be mutated are according to the invention selected in order to obtain additional or fewer attachment groups, such as free amino groups ( $-\text{NH}_2$ ) or free 15 carboxylic acid groups ( $-\text{COOH}$ ), on the surface of the polypeptide and/or to obtain a more complete and broadly spread 5 shielding of the epitope(s) on the surface of the polypeptide.

Conservative substitution

20 It is preferred to make conservative substitutions in the polypeptide, as conservative substitutions secure that the impact of the mutation on the polypeptide structure is limited.

In the case of providing additional amino groups this may be done by substitution of Arginine to Lysine, both residues being 25 positively charged, but only the Lysine having a free amino group suitable as an attachment groups.

In the case of providing additional carboxylic acid groups the conservative substitution may for instance be an Aspargine to Aspartic acid or Glutamine to Glutamic acid substitution.

30 These residues resemble each other in size and shape, except from the carboxylic groups being present on the acidic residues.

In the case of providing fewer attachment groups, e.g. at or 35 close to the active site, a Lysine may be substituted with a Arginine, and so on.

Which amino acids to substitute depends in principle on the coupling chemistry to be applied.

Non-conservative substitution

The mutation may also be on target amino acid residues which are less/non-conservative. Such mutation is suitable for obtaining a more complete and broadly spread shielding of the 5 polypeptide surface than can be obtained by the conservative substitutions.

The method of the invention is first described in general terms, and subsequently using specific examples.

Note the use of the following terms:

10 Attachment\_residue: residue(s) which can bind polymeric molecules, e.g. Lysines (amino group) or Aspartic/Glutamic acids (carboxylic groups). N- or C-terminal amino/carboxylic groups are to be included where relevant.

Mutation\_residue: residue(s) which is to be mutated, e.g. 15 Arginine or Aspargine/Glutamine.

Essential\_catalytic\_residues: residues which are known to be essential for catalytic function, e.g. the catalytic triad in Serine proteases.

Solvent\_exposed\_residues: These are defined as residues which 20 are at least 5% exposed according to the BIOSYM/INSIGHT algorithm found in the module Homology 95.0. The sequence of commands are as follows:

Homology=>ProStat=>Access\_Surf=>Solv\_Radius 1.4; Heavy atoms only; Radii source VdW; Output: Fractional Area; Polarity 25 source: Default. The file filename\_area.tab is produced. Note: For this program to function properly all water molecules must first be removed from the structure.

It looks for example like:

```
# PD498FINALMODEL  
30 # residue area  
TRP_1 136.275711  
SER_2 88.188095  
PRO_3 15.458788  
ASN_4 95.322319  
35 ASP_5 4.903404  
PRO_6 68.096909  
TYR_7 93.333252  
TYR_8 31.791576
```

SER\_9 95.983139

.. continued

1. Identification of residues which are more than 10 Å away  
5 from the closest attachment\_residue, and which are located at  
least 8 Å away from essential\_catalytic\_residues. This residue  
subset is called REST, and is the primary region for  
conservative mutation\_residue to attachment\_residue  
substitutions.

10

2. Identification of residues which are located in a 0-5 Å  
shell around subset REST, but at least 8 Å away from  
essential\_catalytic\_residues. This residue subset is called  
SUB5B. This is a secondary region for conservative  
15 mutation\_residue to attachment\_residue substitutions, as a  
ligand bound to an attachment\_residue in SUB5B will extend into  
the REST region and potentially prevent epitope recognition.

3. Identification of solvent\_exposed mutation\_residues in REST  
20 and SUB5B as potential mutation sites for introduction of  
attachment\_residues.

4. Use BIOSYM/INSIGHT's Biopolymer module and replace residues  
identified under action 3.

25

5. Repeat 1-2 above producing the subset RESTx. This subset  
includes residues which are more than 10 Å away from the  
nearest attachment\_residue, and which are located at least 8 Å  
away from essential catalytic residues.

30

6. Identify solvent\_exposed\_residues in RESTx. These are  
potential sites for less/non-conservative mutations to  
introduce attachment\_residues.

35

Step c) Substituting, inserting or deleting amino acid residues

The mutation(s) performed in step c) may be performed by  
standard techniques well known in the art, such as site-directed

mutagenesis (see, e.g., Sambrook et al. (1989), Sambrook et al., Molecular Cloning. A Laboratory Manual, Cold Spring Harbor, NY.

A general description of nucleotide substitution can be found in e.g. Ford et al., 1991, *Protein Expression and Purification 2*, 5 p. 95-107.

Step d) Coupling polymeric molecules to the modified parent enzyme

Polypeptide-polymer conjugates of the invention may be prepared by any coupling method known in the art including the 10 above mentioned techniques.

Coupling of polymeric molecules to the polypeptide in question

If the polymeric molecules to be conjugated with the polypeptide are not active it must be activated by the use of a 15 suitable method. The polymeric molecules may be coupled to the polypeptide through a linker. Suitable linkers are well known to the skilled person.

Methods and chemistry for activation of polymeric molecules as well as for conjugation of polypeptides are intensively described 20 in the literature. Commonly used methods for activation of insoluble polymers include activation of functional groups with cyanogen bromide, periodate, glutaraldehyde, biepoxides, epichlorohydrin, divinylsulfone, carbodiimide, sulfonyl halides, trichlorotriazine etc. (see R.F. Taylor, (1991), "Protein 25 immobilisation. Fundamental and applications", Marcel Dekker, N.Y.; S.S. Wong, (1992), "Chemistry of Protein Conjugation and Crosslinking", CRC Press, Boca Raton; G.T. Hermanson et al., (1993), "Immobilized Affinity Ligand Techniques", Academic Press, N.Y.). Some of the methods concern activation of insoluble 30 polymers but are also applicable to activation of soluble polymers e.g. periodate, trichlorotriazine, sulfonylhalides, divinylsulfone, carbodiimide etc. The functional groups being amino, hydroxyl, thiol, carboxyl, aldehyde or sulphydryl on the polymer and the chosen attachment group on the protein must be 35 considered in choosing the activation and conjugation chemistry which normally consist of i) activation of polymer, ii) conjugation, and iii) blocking of residual active groups.

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Organic sulfonyl chlorides, e.g. Tresyl chloride, effectively converts hydroxy groups in a number of polymers, e.g. PEG, into good leaving groups (sulfonates) that, when reacted with nucleophiles like amino groups in polypeptides allow stable 35 linkages to be formed between polymer and polypeptide. In addition to high conjugation yields, the reaction conditions are in general mild (neutral or slightly alkaline pH, to avoid denaturation and little or no disruption of activity), and satisfy the non-

destructive requirements to the polypeptide.

Tosylate is more reactive than the mesylate but also more unstable decomposing into PEG, dioxane, and sulfonic acid (Zalipsky, (1995), *Bioconjugate Chem.*, 6, 150-165). Epoxides may 5 also been used for creating amine bonds but are much less reactive than the above mentioned groups.

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Furthermore, isocyanates and isothiocyanates may be employed yielding ureas and thioureas, respectively.

20 Amides may be obtained from PEG acids using the same leaving groups as mentioned above and cyclic imid thrones (US patent no. 5,349,001, (1994), Greenwald et al.). The reactivity of these compounds are very high but may make the hydrolysis to fast.

PEG succinate made from reaction with succinic anhydride can 25 also be used. The hereby comprised ester group make the conjugate much more susceptible to hydrolysis (US patent no. 5,122,614, (1992), Zalipsky). This group may be activated with N-hydroxy succinimide.

Furthermore, a special linker can be introduced. The oldest 30 being cyanuric chloride (Abuchowski et al., (1977), *J. Biol. Chem.*, 252, 3578-3581; US patent no. 4,179,337, (1979), Davis et al.; Shafer et al., (1986), *J. Polym. Sci. Polym. Chem. Ed.*, 24, 375-378.

Coupling of PEG to an aromatic amine followed by diazotation 35 yields a very reactive diazonium salt which *in situ* can be reacted with a peptide. An amide linkage may also be obtained by reacting an azlactone derivative of PEG (US patent no. 5,321,095, (1994), Greenwald, R. B.) thus introducing an additional amide linkage.

As some peptides do not comprise many Lysines it may be advantageous to attach more than one PEG to the same Lysine. This can be done e.g. by the use of 1,3-diamino-2-propanol.

PEGs may also be attached to the amino-groups of the enzyme 5 with carbamate linkages (WO 95/11924, Greenwald et al.). Lysine residues may also be used as the backbone.

#### Addition of attachment groups

##### Specific examples of PD498 variant-SPEG conjugates

10 A specific example of a protease is the parent PD498 (WO 93/24623 and SEQ ID NO. 2). The parent PD498 has a molecular weight of 29 kDa.

Lysine and Arginine residues are located as follows:

Distance from the active site	Arginine	Lysine
0-5 Å	1	
5-10 Å		
10-15 Å	5	6
15-20 Å	2	3
20-25 Å	1	3
total	9	12

15 The inventors examined which parent PD498 sites on the surface may be suitable for introducing additional attachment groups.

A. Suitable conservative Arginine to Lysine substitutions in parent PD498 may be any of R51K, R62K, R121K, R169K, R250K, R28K, R190K.

20 B. Suitable non-conservative substitutions in parent PD498 may be any of P6K, Y7K, S9K, A10K, Y11K, Q12K, D43K, Y44K, N45K, N65K, G87K, I88K, N209K, A211K, N216K, N217K, G218K, Y219K, S220K, Y221K, G262K.

As there is no Lysine residues at or close to the active site 25 there is no need for removing any attachment group.

PD498 variant-SPEG conjugates may be prepared using any of the above mentioned PD498 variants as the starting material by any conjugation technique known in the art for coupling polymeric molecules to amino groups on the enzyme. A specific example is 30 described below.

**Removal of attachment groups****Specific examples of BPN' variant-SPEG conjugates**

A specific example of a protease having an attachment group in 5 the active site is BPN' which has 11 attachment groups (plus an N-terminal amino group): BPN' has a molecular weight of 28 kDa.

Lysine and Arginine residues are located as follows:

Distance from the active site	Arginine	Lysine
0-5 Å		1
5-10 Å		
10-15 Å	1	4
15-20 Å	1	4
20-25 Å		2
<b>total</b>	<b>2</b>	<b>11</b>

10 The Lysine residue located within 0-5 Å of the active site can according to the invention advantageously be removed. Specifically this may be done by a K94R substitution.

BPN' variant-SPEG conjugates may be prepared using the above mentioned BPN' variant as the starting material by any conjugation 15 technique known in the art for coupling polymeric molecules to amino groups on the enzyme.

**Addition and removal of attachment groups****Specific example of Savinase®-SPEG conjugates**

20 As described in Example 2 parent Savinase® (von der Osten et al., (1993), Journal of Biotechnology, 28, p. 55+ and SEQ ID NO. 3) may according to the invention have added a number of amino attachment groups to the surface and removed an amino attachment group close to the active site.

25 Any of the following substitutions in the parent Savinase® are sites for mutagenesis: R10K, R19K, R45K, R145K, R170K, R186K and R247K.

The substitution K94R are identified as a mutation suitable for preventing attachment of polymers close to active site.

30 Savinase® variant-SPEG conjugates may be prepared using any of

the above mentioned Savinase® variants as the starting material by any conjugation technique known in the art for coupling polymeric molecules to amino groups on the enzyme.

##### 5 Addition of attachment groups

###### A specific examples of *Humicola lanuginosa* lipase variants-SPEG conjugates

Specific examples of lipase variants with reduced immunogenicity using the parent *Humicola lanuginosa* DSM 4109 10 lipase (see SEQ ID No 6) as the backbone for substitutions are listed below.

The parent unmodified *Humicola lanuginosa* lipase has 8 attachment groups including the N-terminal NH<sub>2</sub> group and a molecular weight of about 29 kDa.

15 A. Suitable conservative Arginine to Lysine substitutions in the parent lipase may be any of R133K, R139K, R160K, R179K, R209K, R118K and R125K.

Suitable non-conservative substitutions in the parent lipase may be any of:

20 A18K, G31K, T32K, N33K, G38K, A40K, D48K, T50K, E56K, D57K, S58K, G59K, V60K, G61K, D62K, T64K, L78K, N88K, G91K, N92K, L93K, S105K, G106K, V120K, P136K, G225K, L227K, V228K, P229K, P250K, F262K.

Further suitable non-conservative substitution in the *Humicola lanuginosa* lipase include: E87K or D254K.

25 Lipase variant-SPEG conjugates may be prepared using any of the above mentioned lipase variants as the starting material by any conjugation technique known in the art for coupling polymeric molecules to amino groups on the enzyme. A specific example is described below.

30 In Example 12 below is it shown that a conjugate of the *Humicola lanuginosa* lipase variant with a E87K+D254K substitutions coupled to S-PEG 15,000 has reduced immunogenic response in Balb/C mice in comparison to the corresponding parent unmodified enzyme.

##### 35 Immunogenicity and Allergenicity

"Immunogenicity" is a wider term than "antigenicity" and "allergenicity", and expresses the immune system's response to the presence of foreign substances. Said foreign substances are called

immunogens, antigens and allergens depending of the type of immune response the elicit.

An "immunogen" may be defined as a substance which, when introduced into circulatory system of animals and humans, is capable of 5 stimulating an immunologic response resulting in formation of immunoglobulin.

The term "antigen" refers to substances which by themselves are capable of generating antibodies when recognized as a non-self molecule.

10 Further, an "allergen" may be defined as an antigen which may give rise to allergic sensitization or an allergic response by IgE antibodies (in humans, and molecules with comparable effects in animals).

15 Assessment of immunogenicity

Assessment of the immunogenicity may be made by injecting animal subcutaneously to enter the immunogen into the circulation system and comparing the response with the response of the corresponding parent polypeptide.

20 The "circulatory system" of the body of humans and animals means, in the context of the present invention, the system which mainly consists of the heart and blood vessels. The heart delivers the necessary energy for maintaining blood circulation in the vascular system. The circulation system functions as the 25 organism's transportation system, when the blood transports O<sub>2</sub>, nutritious matter, hormones, and other substances of importance for the cell regulation into the tissue. Further the blood removes CO<sub>2</sub> from the tissue to the lungs and residual substances to e.g. the kidneys. Furthermore, the blood is of importance for the 30 temperature regulation and the defence mechanisms of the body, which include the immune system.

A number of *in vitro* animal models exist for assessment of the immunogenic potential of polypeptides. Some of these models give a suitable basis for hazard assessment in man. Suitable models 35 include a mice model.

This model seek to identify the immunogenic response in the form of the IgG response in Balb/C mice being injected subcutaneously with modified and unmodified polypeptides.

Also other animal models can be used for assessment of the immunogenic potential.

A polypeptide having "reduced immunogenicity" according to the invention indicates that the amount of produced antibodies, e.g. 5 immunoglobulin in humans, and molecules with comparable effects in specific animals, which can lead to an immune response, is significantly decreased, when introduced into the circulatory system, in comparison to the corresponding parent polypeptide.

For Balb/C mice the IgG response gives a good indication of the 10 immunogenic potential of polypeptides.

#### Assessment of allergenicity

Assessment of allergenicity may be made by inhalation tests, comparing the effect of intratracheally (into the trachea) 15 administrated parent enzymes with the corresponding modified enzymes according to the invention.

A number of *in vivo* animal models exist for assessment of the allegenicity of enzymes. Some of these models give a suitable basis for hazard assessment in man. Suitable models include a 20 guinea pig model and a mouse model. These models seek to identify respiratory allergens as a function of elicitation reactions induced in previously sensitised animals. According to these models the alleged allergens are introduced intratracheally into the animals.

25 A suitable strain of guinea pigs, the Dunkin Hartley strain, do not as humans, produce IgE antibodies in connection with the allergic response. However, they produce another type of antibody the IgG1A and IgG1B (see e.g. Prentø, ATLA, 19, p. 8-14, 1991), which are responsible for their allergenic response to inhaled 30 polypeptides including enzymes. Therefore, when using the Dunkin Hartley animal model, the relative amount of IgG1A and IgG1B is a measure of the allergenicity level.

The Balb/C mice strain is suitable for intratracheal exposure. Balb/C mice produce IgE as the allergic response.

35 More details on assessing respiratory allergens in guinea pigs and mice is described by Kimber et al., (1996), Fundamental and Applied Toxicology, 33, p. 1-10.

Other animals such as rats, rabbits etc. may also be used for

comparable studies.

Composition

The invention relates to a composition comprising a 5 polypeptide-polymer conjugate of the invention.

The composition may be a pharmaceutical or industrial composition.

The composition may further comprise other polypeptides, 10 proteins or enzymes and/or ingredients normally used in e.g. detergents, including soap bars, household articles, agrochemicals, personal care products, including skin care compositions, cleaning compositions for e.g. contact lenses, oral and dermal pharmaceuticals, composition use for treating textiles, compositions used for manufacturing food, e.g. baking, and feed 15 etc.

Use of the polypeptide-polymer conjugate

The invention also relates to the use of the method of the invention for reducing the immune response of polypeptides.

20 It is also an object of the invention to use the polypeptide-polymer conjugate of the invention to reduce the allergenicity of industrial products, such as detergents, such as laundry, disk wash and hard surface cleaning detergents, and food or feed products.

25

**MATERIAL AND METHODS**

**Materials**

Enzymes:

PD498: Protease of subtilisin type shown in WO 93/24623. The 30 sequence of PD498 is shown in SEQ ID NO. 1 and 2.

Savinase® (Available from Novo Nordisk A/S)

*Humicola lanuginosa* lipase: Available from Novo Nordisk as lipolase® and is further described in EP 305,216. The DNA and protein sequence is shown in SEQ ID NO 5 and 6, respectively.

Strains:

5 *B. subtilis* 309 and 147 are variants of *Bacillus lentinus*, deposited with the NCIB and accorded the accession numbers NCIB 10309 and 10147, and described in US Patent No. 3,723,250 incorporated by reference herein.

10 *E. coli* MC 1000 (M.J. Casadaban and S.N. Cohen (1980); *J. Mol. Biol.* 138 179-207), was made  $r^-, m^+$  by conventional methods and is also described in US Patent Application Serial No. 039,298.

Vectors:

15 pPD498: *E. coli* - *B. subtilis* shuttle vector (described in US patent No. 5,621,089 under section 6.2.1.6) containing the wild-type gene encoding for PD498 protease (SEQ ID NO. 2). The same vector is use for mutagenesis in *E. coli* as well as for expression in *B. subtilis*.

General molecular biology methods:

20 Unless otherwise mentioned the DNA manipulations and transformations were performed using standard methods of molecular biology (Sambrook et al. (1989) Molecular cloning: A laboratory manual, Cold Spring Harbor lab., Cold Spring Harbor, NY; Ausubel, F. M. et al. (eds.) "Current protocols in 25 Molecular Biology". John Wiley and Sons, 1995; Harwood, C. R., and Cutting, S. M. (eds.) "Molecular Biological Methods for *Bacillus*". John Wiley and Sons, 1990). Enzymes for DNA manipulations were used according to the specifications of the suppliers.

30

Materials, chemicals and solutions:

Horse Radish Peroxidase labeled anti-rat-Ig (Dako, DK, P162, # 031; dilution 1:1000).  
35 Mouse anti-rat IgE (Serotec MCA193; dilution 1:200).  
Rat anti-mouse IgE (Serotec MCA419; dilution 1:100).  
Biotin-labeled mouse anti-rat IgG1 monoclonal antibody (Zymed 03-9140; dilution 1:1000)

Biotin-labeled rat anti-mouse IgG1 monoclonal antibody (Serotec MCA336B; dilution 1:1000)

Streptavidin-horse radish peroxidase (Kirkegård & Perry 14-30-00; dilution 1:1000).

5 CovaLink NH<sub>2</sub> plates (Nunc, Cat# 459439)

· Cyanuric chloride (Aldrich)

Acetone (Merck)

Rat anti-Mouse IgG1, biotin (SeroTec, Cat# MCA336B)

Streptavidin, peroxidase (KPL)

10 Ortho-Phenylenediamine (OPD) (Kem-en-Tec)

H<sub>2</sub>O<sub>2</sub>, 30% (Merck)

Tween 20 (Merck)

Skim Milk powder (Difco)

H<sub>2</sub>SO<sub>4</sub> (Merck)

15

Buffers and Solutions:

Carbonate buffer (0.1 M, pH 10 (1 liter)) Na<sub>2</sub>CO<sub>3</sub> 10.60 g

PBS (pH 7.2 (1 liter)) NaCl 8.00 g

KCl 0.20 g

20

K<sub>2</sub>HPO<sub>4</sub> 1.04 g

KH<sub>2</sub>PO<sub>4</sub> 0.32 g

Washing buffer PBS, 0.05% (v/v) Tween 20

Blocking buffer PBS, 2% (wt/v) Skim Milk powder

Dilution buffer PBS, 0.05% (v/v) Tween 20, 0.5% (wt/v) Skim Milk

25 powder

Citrate buffer (0.1M, pH 5.0-5.2 (1 liter)) NaCitrate 20.60 g

Citric acid 6.30 g

Activation of CovaLink plates:

· Make a fresh stock solution of 10 mg cyanuric chloride per ml 30 acetone.

· Just before use, dilute the cyanuric chloride stock solution into PBS, while stirring, to a final concentration of 1mg/ml.

· Add 100 ml of the dilution to each well of the CovaLink NH<sub>2</sub> plates, and incubate for 5 minutes at room temperature.

35 · Wash 3 times with PBS.

· Dry the freshly prepared activated plates at 50°C for 30 minutes.

· Immediately seal each plate with sealing tape.

• Preactivated plates can be stored at room temperature for 3 weeks when kept in a plastic bag.

Sodium Borate, borax (Sigma)

5 3,3-Dimethyl glutaric acid (Sigma)

CaCl<sub>2</sub> (Sigma)

Tresyl chloride (2,2,2-trifluoroethansulfonyl chloride) (Fluka)

1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (EDC) (Fluka)

N-Hydroxy succinimide (Fluka art. 56480))

10 Phosgene (Fluka art. 79380)

Lactose (Merck 7656)

PMSF (phenyl methyl sulfonyl flouride) from Sigma

Succinyl-Alanine-Alanine-Proline-Phenylalanine-para-nitroanilide  
(Suc-AAPF-pNP) Sigma no. S-7388, Mw 624.6 g/mole.

15

Colouring substrate:

OPD: o-phenylene-diamine, (Kementec cat no. 4260)

Test Animals:

20 Dunkin Hartley guinea pigs (from Charles River, DE)

Female Balb/C mice (about 20 grams) purchased from Bomholdtgaard, Ry, Denmark.

Equipment:

25 XCEL II (Novex)

ELISA reader (UVmax, Molecular Devices)

HPLC (Waters)

PFLC (Pharmacia)

Superdex-75 column, Mono-Q, Mono S from Pharmacia, SW.

30 SLT: Fotometer from SLT LabInstruments

Size-exclusion chromatograph (SpheroGel TSK-G2000 SW).

Size-exclusion chromatograph (Superdex 200, Pharmacia, SW)

Amicon Cell

35 Enzymes for DNA manipulations

Unless otherwise mentioned all enzymes for DNA manipulations, such as e.g. restriction endonucleases, ligases etc., are obtained from New England Biolabs. Inc.

**Methods**ELISA procedure for determination of IgG<sub>1</sub> positive guinea pigs

ELISA microtiter plates are coated with rabbit anti-PD498 5 1:8000 in carbonate buffer and incubated over night at 4°C. The next day the plates is blocked with 2% BSA for 1 hour and washes 3 times with PBS Tween 20.

1 µg/ml PD498 is added to the plates and incubated for 1 hour, then washed 3 times with PBS Tween 20.

10 All guinea pig sera samples and controls are applied to the ELISA plates with 2 µl sera and 98 µl PBS, incubated for 1 hour and washed 3 times with PBS Tween 20.

Then goat anti-guinea pig IgG<sub>1</sub> (1:4000 in PBS buffer (Nordic Immunology 44-682)) is applied to the plates, incubated for 1 hour 15 and washed with PBS tween 20.

Alkaline phosphatase marked rabbit anti-goat 1:8000 (Sigma A4187) is applied and incubated for 1 hour, washed 2 times in PBS Tween20 and 1 time with diethanol amine buffer.

The marked alkaline phosphatase is developed using p-20 nitrophenyl phosphate for 30 minutes at 37°C or until appropriate colour has developed.

The reaction is stopped using Stop medium (K<sub>2</sub>HPO<sub>4</sub>/H<sub>2</sub>H<sub>3</sub> buffer comprising EDTA (pH 10)) and read at OD 405/650 using a ELISA reader.

25 Double blinds are included on all ELISA plates.

Positive and negative sera values are calculated as the average blind values added 2 times the standard deviation. This gives an accuracy of 95%.

30 Determination of the molecule weight

Electrophoretic separation of proteins was performed by standard methods using 4-20% gradient SDS poly acrylamide gels (Novex). Proteins were detected by silver staining. The molecule weight was measured relative to the mobility of Mark-12® wide range molecule 35 weight standards from Novex.

Protease activity

Analysis with Suc-Ala-Ala-Pro-Phe-pNa:

Proteases cleave the bond between the peptide and p-nitroaniline to give a visible yellow colour absorbing at 405 nm.

Buffer: e.g. Britton and Robinson buffer pH 8.3

5 Substrate: 100 mg suc-AAPF-pNa is dissolved into 1 ml dimethyl sulfoxide (DMSO). 100 µl of this is diluted into 10 ml with Britton and Robinson buffer.

The substrate and protease solution is mixed and the absorbance is monitored at 405 nm as a function of time and ABS<sub>405</sub> 10 nm/min. The temperature should be controlled (20-50°C depending on protease). This is a measure of the protease activity in the sample.

Proteolytic Activity

15 In the context of this invention proteolytic activity is expressed in Kilo NOVO Protease Units (KNPU). The activity is determined relatively to an enzyme standard (SAVINASE\_), and the determination is based on the digestion of a dimethyl casein (DMC) solution by the proteolytic enzyme at standard 20 conditions, i.e. 50°C, pH 8.3, 9 min. reaction time, 3 min. measuring time. A folder AF 220/1 is available upon request to Novo Nordisk A/S, Denmark, which folder is hereby included by reference.

A GU is a Glycine Unit, defined as the proteolytic enzyme 25 activity which, under standard conditions, during a 15-minutes' incubation at 40°C, with N-acetyl casein as substrate, produces an amount of NH<sub>2</sub>-group equivalent to 1 mmole of glycine.

Enzyme activity can also be measured using the PNA assay, according to reaction with the soluble substrate succinyl-30 alanine-alanine-proline-phenyl-alanine-para-nitrophenol, which is described in the Journal of American Oil Chemists Society, Rothgeb, T.M., Goodlander, B.D., Garrison, P.H., and Smith, L.A., (1988).

35 Fermentation of PD498 variants

Fermentation of PD498 variants in *B. subtilis* are performed at 30°C on a rotary shaking table (300 r.p.m.) in 500 ml baffled Erlenmeyer flasks containing 100 ml BPX medium for 5 days. In

order to make an e.g. 2 liter broth 20 Erlenmeyer flasks are fermented simultaneously.

**Media:**

5 BPX: Composition (per liter)

	Potato starch	100g
	Ground barley	50g
	Soybean flour	20g
	Na <sub>2</sub> HPO <sub>4</sub> X 12 H <sub>2</sub> O	9g
10	Pluronic	0.1g
	Sodium caseinate	10g

The starch in the medium is liquefied with  $\alpha$ -amylase and the medium is sterilized by heating at 120°C for 45 minutes. After sterilization the pH of the medium is adjusted to 9 by 15 addition of NaHCO<sub>3</sub> to 0.1 M.

Purification of PD498 variants

Approximately 1.6 litres of PD498 variant fermentation broth are centrifuged at 5000 rpm for 35 minutes in 1 litre 20 beakers. The supernatants are adjusted to pH 7.0 using 10% acetic acid and filtered on Seitz Supra S100 filter plates. The filtrates are concentrated to approximately 400 ml using an Amicon CH2A UF unit equipped with an Amicon S1Y10 UF cartridge. The UF concentrate is centrifuged and filtered prior to 25 absorption at room temperature on a Bacitracin affinity column at pH 7. The PD498 variant is eluted from the Bacitracin column at room temperature using 25% 2-propanol and 1 M sodium chloride in a buffer solution with 0.01 dime-thyl-glutaric acid, 0.1 M boric acid and 0.002 M calcium chloride adjusted to 30 pH 7.

The fractions with protease activity from the Bacitracin purification step are combined and applied to a 750 ml Sephadex G25 column (5 cm diameter) equilibrated with a buffer containing 0.01 dimethylglutaric acid, 0.1 M boric acid and 35 0.002 M calcium chloride adjusted to pH 6.0.

Fractions with proteolytic activity from the Sephadex G25 column are combined and applied to a 150 ml CM Sepharose CL 6B cat-ion exchange column (5 cm diameter) equilibrated with a

buffer containing 0.01 M dimethylglutaric acid, 0.1 M boric acid, and 0.002 M calcium chloride adjusted to pH 6.0.

The protease is eluted using a linear gradient of 0-0.5 M sodium chloride in 1 litres of the same buffer.

5 Protease containing fractions from the CM Sepharose column are combined and filtered through a 2 $\mu$  filter.

Balb/C mice IgG ELISA Procedure:

- The antigen is diluted to 1 mg/ml in carbonate buffer.
- 10 · 100 ml is added to each well.
- The plates are coated overnight at 4°C.
- Unspecific adsorption is blocked by incubating each well for 1 hour at room temperature with 200 ml blocking buffer.
- The plates are washed 3x with 300 ml washing buffer.
- 15 · Unknown mouse sera are diluted in dilution buffer, typically 10x, 20x and 40x, or higher.
- 100 ml is added to each well.
- Incubation is for 1 hour at room temperature.
- Unbound material is removed by washing 3x with washing buffer.
- 20 · The anti-Mouse IgG1 antibody is diluted 2000x in dilution buffer.
- 100 ml is added to each well.
- Incubation is for 1 hour at room temperature.
- Unbound material is removed by washing 3x with washing buffer.
- 25 · Streptavidine is diluted 1000x in dilution buffer.
- 100 ml is added to each well.
- Incubation is for 1 hour at room temperature.
- Unbound material is removed by washing 3x with 300 ml washing buffer.
- 30 · OPD (0.6 mg/ml) and H<sub>2</sub>O<sub>2</sub> (0.4 ml/ml) is dissolved in citrate buffer.
- 100 ml is added to each well.
- Incubation is for 10 minutes at room temperature.
- The reaction is stopped by adding 100 ml H<sub>2</sub>SO<sub>4</sub>.
- 35 · The plates are read at 492 nm with 620 nm as reference.

Immunisation of mice

Balb/C mice (20 grams) are immunised 10 times (intervals of 14

days) by subcutaneous injection of the modified or unmodified polypeptide in question, respectively by standard procedures known in art.

## 5 EXAMPLES

### Example 1

#### Suitable substitutions in PD498 for addition of amino attachment groups (-NH<sub>2</sub>)

The 3D structure of parent PD498 was modeled as described above based on 59% sequence identity with Thermitase® (2tec.pdb).

The sequence of PD498 is (see SEQ ID NO. 2). PD498 residue numbering is used, 1-280.

The commands performed in Insight (BIOSYM) are shown in the command files makeKzone.bcl and makeKzone2.bcl below:

#### Conservative substitutions:

```
20 makeKzone.bcl
 1 Delete Subset *
 2 Color Molecule Atoms * Specified Specification 55,0,255
 3 Zone Subset LYS :lys:NZ Static monomer/residue 10
 Color_Subset 255,255,0
 25 4 Zone Subset NTERM :1:N Static monomer/residue 10
 Color_Subset 255,255,0
 5 #NOTE: editnextline ACTSITE residues according to the
 protein
 6 Zone Subset ACTSITE :39,72,226 Static monomer/residue 8
 30 Color_Subset 255,255,0
 7 Combine Subset ALLZONE Union LYS NTERM
 8 Combine Subset ALLZONE Union ALLZONE ACTSITE
 9 #NOTE: editnextline object name according to the protein
 10 Combine Subset REST Difference PD498FINALMODEL ALLZONE
 35 11 List Subset REST Atom Output File restatom.list
 12 List Subset REST monomer/residue Output File restmole.list
 13 Color Molecule Atoms ACTSITE Specified Specification 255,0,0
 14 List Subset ACTSITE Atom Output File actsiteatom.list
 15 List Subset ACTSITE monomer/residue Output File
 40 actsitemole.list
 16 #
 17 Zone Subset REST5A REST Static Monomer/Residue 5 -
 Color_Subset
 18 Combine Subset SUB5A Difference REST5A ACTSITE
 45 19 Combine Subset SUB5B Difference SUB5A REST
 20 Color Molecule Atoms SUB5B Specified Specification
 255,255,255
 21 List Subset SUB5B Atom Output File sub5batom.list
 22 List Subset SUB5B monomer/residue Output File sub5bmole.list
```

```

23 #Now identify sites for lys->arg substitutions and continue
with makezone2.bcl
24 #Use grep command to identify ARG in restatom.list,
sub5batom.list & accsiteatom.list

```

5

Comments:

Lines 1-8: The subset ALLZONE is defined as those residues which are either within 10 Å of the free amino groups on lysines or the N-terminal, or within 8 Å of the catalytic triad residues 39, 72 and 226.

Line 10: The subset REST is defined as those residues not included in ALLZONE.

Lines 17-20: Subset SUB5B is defined as those residues in a 5 Å shell around REST, excluding residues within 8 Å of the catalytic residues.

Line 23-24: REST contains Arg62 and Arg169, SUB5B contains Arg51, Arg121, and Arg250. ACTSITE contains Arg103, but position 103 is within 8 Å from essential\_catalytic\_residues, and thus not relevant.

20 The colour codes are: (255,0,255) = magenta, (255,255,0) yellow, (255,0,0) red, and (255, 255, 255)= white.

The substitutions R51K, R62K, R121K, R169K and R250K are identified in parent PD498 as suitable sites for mutagenesis. The residues are substituted below in section 2, and further 25 analysis done:

Non-conservative substitutions:

makeKzone2.bcl

```

1  #sourcefile makezone2.bcl  Claus von der Osten  961128
30 2  #
3  #having scanned lists (grep arg command) and identified
sites for lys->arg substitutions
4  #NOTE: editnextline object name according to protein
5  Copy Object -To_Clipboard -Displace PD498FINALMODEL
35 newmodel
6  Biopolymer
7  #NOTE: editnextline object name according to protein
8  Blank Object On PD498FINALMODEL
9  #NOTE: editnextlines with lys->arg positions
40 10 Replace Residue newmodel:51 lys L
11 Replace Residue newmodel:62 lys L
12 Replace Residue newmodel:121 lys L
13 Replace Residue newmodel:169 lys L
14 Replace Residue newmodel:250 lys L
45 15 #

```

```

16 #Now repeat analysis done prior to arg->lys, now including
17 introduced lysines
18 Color Molecule Atoms newmodel Specified Specification
255,0,255
5 18 Zone Subset LYSx newmodel:lys:NZ Static monomer/residue 10
Color_Subset 255,255,0
19 Zone Subset NTERMx newmodel:1:N Static monomer/residue 10
Color_Subset 255,255,0
20 #NOTE: editnextline ACTSITEx residues according to the
10 protein
21 Zone Subset ACTSITEx newmodel:39,72,226 Static
monomer/residue 8 Color_Subset 255,255,0
22 Combine Subset ALLZONEx Union LYSx NTERMx
23 Combine Subset ALLZONEx Union ALLZONEx ACTSITEx
15 24 Combine Subset RESTx Difference newmodel ALLZONEx
25 List Subset RESTx Atom Output_File restxatom.list
26 List Subset RESTx monomer/residue Output_File
restxmole.list
27 #
20 28 Color Molecule Atoms ACTSITEx Specified Specification
255,0,0
29 List Subset ACTSITEx Atom Output_File actsitexatom.list
30 List Subset ACTSITEx monomer/residue Output_File
actsitexmole.list
25 31 #
32 #read restxatom.list or restxmole.list to identify sites
for (not_arg)->lys subst. if needed

```

Comments:

30 Lines 1-15: Solvent exposed arginines in subsets REST and SUB5B are replaced by lysines. Solvent accessibilities are recalculated following arginine replacement.

Lines 16-23: The subset ALLZONEx is defined as those residues which are either within 10 Å of the free amino groups 35 on Lysines (after replacement) or the N-terminal, or within 8 Å of the catalytic triad residues 39, 72 and 226.

Line 24-26: The subset RESTx is defined as those residues not included in ALLZONEx, i.e. residues which are still potential epitope contributors. Of the residues in RESTx, the 40 following are >5% exposed (see lists below): 6-7,9-12,43-45,65,87-88,209,211,216-221,262.

The following mutations are proposed in parent PD498: P6K, Y7K, S9K, A10K, Y11K, Q12K, D43K, Y44K, N45K, N65K, G87K, I88K, N209K, A211K, N216K, N217K, G218K, Y219K, S220K, Y221K, G262K.

45 Relevant data for Example 1:

Solvent accessibility data for PD498MODEL:

```

# PD498MODEL      Fri Nov 29 10:24:48 MET 1996
# residue area

```

	TRP_1	136.275711
	SER_2	88.188095
	PRO_3	15.458788
	ASN_4	95.322319
5	ASP_5	4.903404
	PRO_6	68.096909
	TYR_7	93.333252
	TYR_8	31.791576
	SER_9	95.983139
10	ALA_10	77.983536
	TYR_11	150.704727
	GLN_12	26.983349
	TYR_13	44.328232
	GLY_14	3.200084
15	PRO_15	2.149547
	GLN_16	61.385445
	ASN_17	37.776707
	THR_18	1.237873
	SER_19	41.031750
20	THR_20	4.321402
	PRO_21	16.658991
	ALA_22	42.107288
	ALA_23	0.000000
	TRP_24	3.713619
25	ASP_25	82.645493
	VAL_26	74.397812
	THR_27	14.950654
	ARG_28	110.606209
	GLY_29	0.242063
30	SER_30	57.225292
	SER_31	86.986198
	THR_32	1.928865
	GLN_33	42.008949
	THR_34	0.502189
35	VAL_35	0.268693
	ALA_36	0.000000
	VAL_37	5.255383
	LEU_38	1.550332
	ASP_39	3.585718
40	SER_40	2.475746
	GLY_41	4.329043
	VAL_42	1.704864
	ASP_43	25.889742
	TYR_44	89.194855
45	ASN_45	109.981819
	HIS_46	0.268693
	PRO_47	66.580925
	ASP_48	0.000000
	LEU_49	0.770882
50	ALA_50	49.618046
	ARG_51	218.751709
	LYS_52	18.808538
	VAL_53	39.937984
	ILE_54	98.478104
55	LYS_55	103.612228
	GLY_56	17.199390
	TYR_57	67.719147

	ASP_58	0.000000
	PHE_59	40.291119
	ILE_60	50.151962
	ASP_61	70.078888
5	ARG_62	166.777557
	ASP_63	35.892376
	ASN_64	120.641953
	ASN_65	64.982895
	PRO_66	6.986028
10	MET_67	58.504269
	ASP_68	28.668840
	LEU_69	104.467468
	ASN_70	78.460953
	GLY_71	5.615932
15	HIS_72	43.158905
	GLY_73	0.268693
	THR_74	0.000000
	HIS_75	0.484127
	VAL_76	1.880854
20	ALA_77	0.000000
	GLY_78	0.933982
	THR_79	9.589676
	VAL_80	0.000000
	ALA_81	0.000000
25	ALA_82	0.000000
	ASP_83	46.244987
	THR_84	27.783333
	ASN_85	75.924225
	ASN_86	44.813908
30	GLY_87	50.453152
	ILE_88	74.428070
	GLY_89	4.115077
	VAL_90	6.717335
	ALA_91	2.872341
35	GLY_92	0.233495
	MET_93	5.876057
	ALA_94	0.000000
	PRO_95	17.682203
	ASP_96	83.431740
40	THR_97	1.506567
	LYS_98	72.674973
	ILE_99	4.251006
	LEU_100	6.717335
	ALA_101	0.806080
45	VAL_102	1.426676
	ARG_103	2.662697
	VAL_104	2.171855
	LEU_105	18.808538
	ASP_106	52.167435
50	ALA_107	52.905663
	ASN_108	115.871315
	GLY_109	30.943356
	SER_110	57.933651
	GLY_111	50.705326
55	SER_112	56.383320
	LEU_113	71.312195
	ASP_114	110.410919

	SER_115	13.910152
	ILE_116	22.570246
	ALA_117	5.642561
	SER_118	29.313131
5	GLY_119	0.000000
	ILE_120	1.343467
	ARG_121	118.391129
	TYR_122	44.203033
	ALA_123	0.000000
10	ALA_124	7.974043
	ASP_125	83.851639
	GLN_126	64.311974
	GLY_127	36.812618
	ALA_128	4.705107
15	LYS_129	90.886139
	VAL_130	1.039576
	LEU_131	2.149547
	ASN_132	4.315227
	LEU_133	1.880854
20	SER_134	3.563334
	LEU_135	26.371397
	GLY_136	59.151070
	CYS_137	63.333755
	GLU_138	111.553314
25	CYS_139	83.591461
	ASN_140	80.757843
	SER_141	25.899158
	THR_142	99.889725
	THR_143	73.323814
30	LEU_144	5.589301
	LYS_145	94.708755
	SER_146	72.636993
	ALA_147	9.235920
	VAL_148	1.612160
35	ASP_149	57.431465
	TYR_150	106.352493
	ALA_151	0.268693
	TRP_152	43.133667
	ASN_153	112.864975
40	LYS_154	110.009468
	GLY_155	33.352180
	ALA_156	3.493014
	VAL_157	1.048144
	VAL_158	2.043953
45	VAL_159	0.000000
	ALA_160	0.537387
	ALA_161	10.872165
	ALA_162	7.823834
	GLY_163	12.064573
50	ASN_164	81.183388
	ASP_165	64.495300
	ASN_166	83.457443
	VAL_167	68.516815
	SER_168	78.799652
55	ARG_169	116.937134
	THR_170	57.275074
	PHE_171	51.416462

	GLN_172	18.934589
	PRO_173	1.880854
	ALA_174	6.522357
	SER_175	26.184139
5	TYR_176	21.425076
	PRO_177	85.613541
	ASN_178	34.700817
	ALA_179	0.268693
	ILE_180	1.074774
10	ALA_181	3.761708
	VAL_182	0.000000
	GLY_183	2.149547
	ALA_184	0.951118
	ILE_185	0.806080
15	ASP_186	30.022263
	SER_187	72.518509
	ASN_188	117.128021
	ASP_189	47.601345
	ARG_190	150.050873
20	LYS_191	64.822807
	ALA_192	2.686934
	SER_193	96.223808
	PHE_194	51.482613
	SER_195	1.400973
25	ASN_196	4.148808
	TYR_197	80.937309
	GLY_198	10.747736
	THR_199	93.221252
	TRP_200	169.943604
30	VAL_201	15.280325
	ASP_202	12.141763
	VAL_203	0.268693
	THR_204	3.409728
	ALA_205	0.000000
35	PRO_206	0.000000
	GLY_207	0.000000
	VAL_208	37.137192
	ASN_209	78.286270
	ILE_210	9.404268
40	ALA_211	25.938599
	SER_212	5.037172
	THR_213	0.000000
	VAL_214	22.301552
	PRO_215	45.251030
45	ASN_216	131.014160
	ASN_217	88.383461
	GLY_218	21.226780
	TYR_219	88.907570
	SER_220	39.966541
50	TYR_221	166.037018
	MET_222	50.951096
	SER_223	54.435001
	GLY_224	1.880854
	THR_225	1.634468
55	SER_226	17.432346
	MET_227	7.233279
	ALA_228	0.000000

	SER_229	0.000000
	PRO_230	0.268693
	HIS_231	2.680759
	VAL_232	0.000000
5	ALA_233	0.000000
	GLY_234	1.074774
	LEU_235	11.500556
	ALA_236	0.000000
	ALA_237	0.000000
10	LEU_238	1.612160
	LEU_239	0.000000
	ALA_240	10.648088
	SER_241	39.138004
	GLN_242	71.056175
15	GLY_243	66.487144
	LYS_244	43.256012
	ASN_245	80.728127
	ASN_246	34.859673
	VAL_247	84.145645
20	GLN_248	51.819775
	ILE_249	8.598188
	ARG_250	35.055809
	GLN_251	71.928093
	ALA_252	0.000000
25	ILE_253	4.845899
	GLU_254	13.344438
	GLN_255	81.705254
	THR_256	9.836061
	ALA_257	2.810513
30	ASP_258	44.656136
	LYS_259	113.071686
	ILE_260	32.089527
	SER_261	91.590103
	GLY_262	26.450439
35	THR_263	38.308762
	GLY_264	46.870056
	THR_265	88.551804
	ASN_266	34.698349
	PHE_267	7.756911
40	LYS_268	103.212852
	TYR_269	37.638382
	GLY_270	0.000000
	LYS_271	11.376978
	ILE_272	2.885231
45	ASN_273	19.195255
	SER_274	2.651736
	ASN_275	38.177547
	LYS_276	84.549576
	ALA_277	1.074774
50	VAL_278	4.775503
	ARG_279	162.693054
	TYR_280	96.572929
	CA_281	0.000000
	CA_282	0.000000
55	CA_283	8.803203

Subset REST:

```
restmole.list
Subset REST:
PD498FINALMODEL:6-7,9-12,43-46,61-63,65,87-
89,111-114,117-118,131,
5 PD498FINALMODEL:137-139,158-159,169-171,173-
174,180-181,209,211,
PD498FINALMODEL:216-221,232-233,262,E282H
restatom.list
Subset REST:
10 PD498FINALMODEL:PRO 6:N,CA,CD,C,O,CB,CG
PD498FINALMODEL:TYR 7:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
PD498FINALMODEL:SER 9:N,CA,C,O,CB,OG
PD498FINALMODEL:ALA 10:N,CA,C,O,CB
PD498FINALMODEL:TYR 11:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
15 PD498FINALMODEL:GLN 12:N,CA,C,O,CB,CG,CD,OE1,NE2
PD498FINALMODEL:ASP 43:N,CA,C,O,CB,CG,OD1,OD2
PD498FINALMODEL:TYR
44:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
PD498FINALMODEL:ASN 45:N,CA,C,O,CB,CG,OD1,ND2
20 PD498FINALMODEL:HIS
46:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2
PD498FINALMODEL:ASP 61:N,CA,C,O,CB,CG,OD1,OD2
PD498FINALMODEL:ARG
62:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2
25 PD498FINALMODEL:ASP 63:N,CA,C,O,CB,CG,OD1,OD2
PD498FINALMODEL:ASN 65:N,CA,C,O,CB,CG,OD1,ND2
PD498FINALMODEL:GLY 87:N,CA,C,O
PD498FINALMODEL:ILE 88:N,CA,C,O,CB,CG1,CG2,CD1
PD498FINALMODEL:GLY 89:N,CA,C,O
30 PD498FINALMODEL:GLY 111:N,CA,C,O
PD498FINALMODEL:SER 112:N,CA,C,O,CB,OG
PD498FINALMODEL:LEU 113:N,CA,C,O,CB,CG,CD1,CD2
PD498FINALMODEL:ASP 114:N,CA,C,O,CB,CG,OD1,OD2
PD498FINALMODEL:ALA 117:N,CA,C,O,CB
35 PD498FINALMODEL:SER 118:N,CA,C,O,CB,OG
PD498FINALMODEL:LEU 131:N,CA,C,O,CB,CG,CD1,CD2
PD498FINALMODEL:CYS 137:N,CA,C,O,CB,SG
PD498FINALMODEL:GLU
138:N,CA,C,O,CB,CG,CD,OE1,OE2
40 PD498FINALMODEL:CYS 139:N,CA,C,O,CB,SG
PD498FINALMODEL:VAL 158:N,CA,C,O,CB,CG1,CG2
PD498FINALMODEL:VAL 159:N,CA,C,O,CB,CG1,CG2
PD498FINALMODEL:ARG
169:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2
45 PD498FINALMODEL:THR 170:N,CA,C,O,CB,OG1,CG2
PD498FINALMODEL:PHE
171:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ
PD498FINALMODEL:PRO 173:N,CA,CD,C,O,CB,CG
PD498FINALMODEL:ALA 174:N,CA,C,O,CB
50 PD498FINALMODEL:ILE 180:N,CA,C,O,CB,CG1,CG2,CD1
PD498FINALMODEL:ALA 181:N,CA,C,O,CB
PD498FINALMODEL:ASN 209:N,CA,C,O,CB,CG,OD1,ND2
PD498FINALMODEL:ALA 211:N,CA,C,O,CB
PD498FINALMODEL:ASN 216:N,CA,C,O,CB,CG,OD1,ND2
55 PD498FINALMODEL:ASN 217:N,CA,C,O,CB,CG,OD1,ND2
PD498FINALMODEL:GLY 218:N,CA,C,O
```

PD498FINALMODEL: TYR  
219:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
PD498FINALMODEL: SER 220:N,CA,C,O,CB,OG  
PD498FINALMODEL: TYR  
5 221:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
PD498FINALMODEL: VAL 232:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL: ALA 233:N,CA,C,O,CB  
PD498FINALMODEL: GLY 262:N,CA,C,O  
PD498FINALMODEL: CA E282H:CA  
10  
Subset SUB5B:  
sub5b.mole.list  
Subset SUB5B:  
PD498FINALMODEL: 4-5,8,13-16,34-35,47-  
15 51,53,64,83,85-86,90-91,120-124,  
PD498FINALMODEL: 128-130,140-141,143-144,147-  
148,151-152,156-157,  
PD498FINALMODEL: 165,167-168,172,175-176,178-  
179,196,200-205,208,  
20 PD498FINALMODEL: 234-237,250,253-254,260-261,263-  
267,272,E281H,  
PD498FINALMODEL: E283H  
  
sub5b.atom.list  
25 Subset SUB5B:  
PD498FINALMODEL: ASN 4:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL: ASP 5:N,CA,C,O,CB,CG,OD1,OD2  
PD498FINALMODEL: TYR  
8:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
30 PD498FINALMODEL: TYR  
13:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
PD498FINALMODEL: GLY 14:N,CA,C,O  
PD498FINALMODEL: PRO 15:N,CA,CD,C,O,CB,CG  
PD498FINALMODEL: GLN 16:N,CA,C,O,CB,CG,CD,OE1,NE2  
35 PD498FINALMODEL: THR 34:N,CA,C,O,CB,OG1,CG2  
PD498FINALMODEL: VAL 35:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL: PRO 47:N,CA,CD,C,O,CB,CG  
PD498FINALMODEL: ASP 48:N,CA,C,O,CB,CG,OD1,OD2  
PD498FINALMODEL: LEU 49:N,CA,C,O,CB,CG,CD1,CD2  
40 PD498FINALMODEL: ALA 50:N,CA,C,O,CB  
PD498FINALMODEL: ARG  
51:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
PD498FINALMODEL: VAL 53:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL: ASN 64:N,CA,C,O,CB,CG,OD1,ND2  
45 PD498FINALMODEL: ASP 83:N,CA,C,O,CB,CG,OD1,OD2  
PD498FINALMODEL: ASN 85:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL: ASN 86:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL: VAL 90:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL: ALA 91:N,CA,C,O,CB  
50 PD498FINALMODEL: ILE 120:N,CA,C,O,CB,CG1,CG2,CD1  
PD498FINALMODEL: ARG  
121:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
PD498FINALMODEL: TYR  
122:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
55 PD498FINALMODEL: ALA 123:N,CA,C,O,CB  
PD498FINALMODEL: ALA 124:N,CA,C,O,CB  
PD498FINALMODEL: ALA 128:N,CA,C,O,CB

PD498FINALMODEL:LYS 129:N,CA,C,O,CB,CG,CD,CE,NZ  
 PD498FINALMODEL:VAL 130:N,CA,C,O,CB,CG1,CG2  
 PD498FINALMODEL:ASN 140:N,CA,C,O,CB,CG,OD1,ND2  
 PD498FINALMODEL:SER 141:N,CA,C,O,CB,OG  
 5 PD498FINALMODEL:THR 143:N,CA,C,O,CB,OG1,CG2  
 PD498FINALMODEL:LEU 144:N,CA,C,O,CB,CG,CD1,CD2  
 PD498FINALMODEL:ALA 147:N,CA,C,O,CB  
 PD498FINALMODEL:VAL 148:N,CA,C,O,CB,CG1,CG2  
 PD498FINALMODEL:ALA 151:N,CA,C,O,CB  
 10 PD498FINALMODEL:TRP  
     52:N,CA,C,O,CB,CG,CD1,CD2,NE1,CE2,CE3,  
     CZ2,CZ3,CH2  
 PD498FINALMODEL:ALA 156:N,CA,C,O,CB  
 PD498FINALMODEL:VAL 157:N,CA,C,O,CB,CG1,CG2  
 15 PD498FINALMODEL:ASP 165:N,CA,C,O,CB,CG,OD1,OD2  
 PD498FINALMODEL:VAL 167:N,CA,C,O,CB,CG1,CG2  
 PD498FINALMODEL:SER 168:N,CA,C,O,CB,OG  
 PD498FINALMODEL:GLN  
     172:N,CA,C,O,CB,CG,CD,OE1,NE2  
 20 PD498FINALMODEL:SER 175:N,CA,C,O,CB,OG  
 PD498FINALMODEL:TYR  
     176:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 PD498FINALMODEL:ASN 178:N,CA,C,O,CB,CG,OD1,ND2  
 PD498FINALMODEL:ALA 179:N,CA,C,O,CB  
 25 PD498FINALMODEL:ASN 196:N,CA,C,O,CB,CG,OD1,ND2  
 PD498FINALMODEL:TRP  
     200:N,CA,C,O,CB,CG,CD1,CD2,NE1,CE2,CE3,  
     CZ2,CZ3,CH2  
 PD498FINALMODEL:VAL 201:N,CA,C,O,CB,CG1,CG2  
 30 PD498FINALMODEL:ASP 202:N,CA,C,O,CB,CG,OD1,OD2  
 PD498FINALMODEL:VAL 203:N,CA,C,O,CB,CG1,CG2  
 PD498FINALMODEL:THR 204:N,CA,C,O,CB,OG1,CG2  
 PD498FINALMODEL:ALA 205:N,CA,C,O,CB  
 PD498FINALMODEL:VAL 208:N,CA,C,O,CB,CG1,CG2  
 35 PD498FINALMODEL:GLY 234:N,CA,C,O  
 PD498FINALMODEL:LEU 235:N,CA,C,O,CB,CG,CD1,CD2  
 PD498FINALMODEL:ALA 236:N,CA,C,O,CB  
 PD498FINALMODEL:ALA 237:N,CA,C,O,CB  
 PD498FINALMODEL:ARG  
     250:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 40 PD498FINALMODEL:ILE 253:N,CA,C,O,CB,CG1,CG2,CD1  
 PD498FINALMODEL:GLU  
     254:N,CA,C,O,CB,CG,CD,OE1,OE2  
 PD498FINALMODEL:ILE 260:N,CA,C,O,CB,CG1,CG2,CD1  
 45 PD498FINALMODEL:SER 261:N,CA,C,O,CB,OG  
 PD498FINALMODEL:THR 263:N,CA,C,O,CB,OG1,CG2  
 PD498FINALMODEL:GLY 264:N,CA,C,O  
 PD498FINALMODEL:THR 265:N,CA,C,O,CB,OG1,CG2  
 PD498FINALMODEL:ASN 266:N,CA,C,O,CB,CG,OD1,ND2  
 50 PD498FINALMODEL:PHE  
     267:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 PD498FINALMODEL:ILE 272:N,CA,C,O,CB,CG1,CG2,CD1  
 PD498FINALMODEL:CA E281H:CA  
 PD498FINALMODEL:CA E283H:NA

55

Subset ACTSITE:  
 actsitemole.list

## Subset ACTSITE:

PD498FINALMODEL: 36-42, 57-60, 66-80, 100-110, 115-  
 116, 119, 132-136, 160-164,  
 PD498FINALMODEL: 182-184, 194, 206-207, 210, 212-  
 5 215, 222-231

## actsiteatom.list

## Subset ACTSITE:

PD498FINALMODEL: ALA 36:N, CA, C, O, CB  
 10 PD498FINALMODEL: VAL 37:N, CA, C, O, CB, CG1, CG2  
 PD498FINALMODEL: LEU 38:N, CA, C, O, CB, CG, CD1, CD2  
 PD498FINALMODEL: ASP 39:N, CA, C, O, CB, CG, OD1, OD2  
 PD498FINALMODEL: SER 40:N, CA, C, O, CB, OG  
 PD498FINALMODEL: GLY 41:N, CA, C, O  
 15 PD498FINALMODEL: VAL 42:N, CA, C, O, CB, CG1, CG2  
 PD498FINALMODEL: TYR 57:N, CA, C, O, CB, CG, CD1, CD2, CE1, CE2, CZ, OH  
 PD498FINALMODEL: ASP 58:N, CA, C, O, CB, CG, OD1, OD2  
 PD498FINALMODEL: PHE 59:N, CA, C, O, CB, CG, CD1, CD2, CE1, CE2, CZ  
 20 PD498FINALMODEL: ILE 60:N, CA, C, O, CB, CG1, CG2, CD1  
 PD498FINALMODEL: PRO 66:N, CA, CD, C, O, CB, CG  
 PD498FINALMODEL: MET 67:N, CA, C, O, CB, CG, SD, CE  
 PD498FINALMODEL: ASP 68:N, CA, C, O, CB, CG, OD1, OD2  
 25 PD498FINALMODEL: LEU 69:N, CA, C, O, CB, CG, CD1, CD2  
 PD498FINALMODEL: ASN 70:N, CA, C, O, CB, CG, OD1, ND2  
 PD498FINALMODEL: GLY 71:N, CA, C, O  
 PD498FINALMODEL: HIS 72:N, CA, C, O, CB, CG, ND1, CD2, CE1, NE2  
 30 PD498FINALMODEL: GLY 73:N, CA, C, O  
 PD498FINALMODEL: THR 74:N, CA, C, O, CB, OG1, CG2  
 PD498FINALMODEL: HIS 75:N, CA, C, O, CB, CG, ND1, CD2, CE1, NE2  
 PD498FINALMODEL: VAL 76:N, CA, C, O, CB, CG1, CG2  
 35 PD498FINALMODEL: ALA 77:N, CA, C, O, CB  
 PD498FINALMODEL: GLY 78:N, CA, C, O  
 PD498FINALMODEL: THR 79:N, CA, C, O, CB, OG1, CG2  
 PD498FINALMODEL: VAL 80:N, CA, C, O, CB, CG1, CG2  
 PD498FINALMODEL: LEU 100:N, CA, C, O, CB, CG, CD1, CD2  
 40 PD498FINALMODEL: ALA 101:N, CA, C, O, CB  
 PD498FINALMODEL: VAL 102:N, CA, C, O, CB, CG1, CG2  
 PD498FINALMODEL: ARG 103:N, CA, C, O, CB, CG, CD, NE, CZ, NH1, NH2  
 PD498FINALMODEL: VAL 104:N, CA, C, O, CB, CG1, CG2  
 45 PD498FINALMODEL: LEU 105:N, CA, C, O, CB, CG, CD1, CD2  
 PD498FINALMODEL: ASP 106:N, CA, C, O, CB, CG, OD1, OD2  
 PD498FINALMODEL: ALA 107:N, CA, C, O, CB  
 PD498FINALMODEL: ASN 108:N, CA, C, O, CB, CG, OD1, ND2  
 PD498FINALMODEL: GLY 109:N, CA, C, O  
 50 PD498FINALMODEL: SER 110:N, CA, C, O, CB, OG  
 PD498FINALMODEL: SER 115:N, CA, C, O, CB, OG  
 PD498FINALMODEL: ILE 116:N, CA, C, O, CB, CG1, CG2, CD1  
 PD498FINALMODEL: GLY 119:N, CA, C, O  
 PD498FINALMODEL: ASN 132:N, CA, C, O, CB, CG, OD1, ND2  
 55 PD498FINALMODEL: LEU 133:N, CA, C, O, CB, CG, CD1, CD2  
 PD498FINALMODEL: SER 134:N, CA, C, O, CB, OG  
 PD498FINALMODEL: LEU 135:N, CA, C, O, CB, CG, CD1, CD2

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PD498FINALMODEL:GLY 136:N,CA,C,O
PD498FINALMODEL:ALA 160:N,CA,C,O,CB
PD498FINALMODEL:ALA 161:N,CA,C,O,CB
PD498FINALMODEL:ALA 162:N,CA,C,O,CB
5 PD498FINALMODEL:GLY 163:N,CA,C,O
PD498FINALMODEL:ASN 164:N,CA,C,O,CB,CG,OD1,ND2
PD498FINALMODEL:VAL 182:N,CA,C,O,CB,CG1,CG2
PD498FINALMODEL:GLY 183:N,CA,C,O
PD498FINALMODEL:ALA 184:N,CA,C,O,CB
10 PD498FINALMODEL:PHE
    194:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ
PD498FINALMODEL:PRO 206:N,CA,CD,C,O,CB,CG
PD498FINALMODEL:GLY 207:N,CA,C,O
PD498FINALMODEL:ILE 210:N,CA,C,O,CB,CG1,CG2,CD1
15 PD498FINALMODEL:SER 212:N,CA,C,O,CB,OG
PD498FINALMODEL:THR 213:N,CA,C,O,CB,OG1,CG2
PD498FINALMODEL:VAL 214:N,CA,C,O,CB,CG1,CG2
PD498FINALMODEL:PRO 215:N,CA,CD,C,O,CB,CG
PD498FINALMODEL:MET 222:N,CA,C,O,CB,CG,SD,CE
20 PD498FINALMODEL:SER 223:N,CA,C,O,CB,OG
PD498FINALMODEL:GLY 224:N,CA,C,O
PD498FINALMODEL:THR 225:N,CA,C,O,CB,OG1,CG2
PD498FINALMODEL:SER 226:N,CA,C,O,CB,OG
PD498FINALMODEL:MET 227:N,CA,C,O,CB,CG,SD,CE
25 PD498FINALMODEL:ALA 228:N,CA,C,O,CB
PD498FINALMODEL:SER 229:N,CA,C,O,CB,OG
PD498FINALMODEL:PRO 230:N,CA,CD,C,O,CB,CG
PD498FINALMODEL:HIS
    231:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2
30 Subset RESTx:
    restxmole.list
Subset RESTX:
    NEWMODEL:6-7,9-12,43-46,65,87-
35 89,131,173,209,211,216-221,232-233,
    NEWMODEL:262,E282H

    restxatom.list
Subset RESTX:
40    NEWMODEL:PRO 6:N,CA,CD,C,O,CB,CG
    NEWMODEL:TYR
    7:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
    NEWMODEL:SER 9:N,CA,C,O,CB,OG
    NEWMODEL:ALA 10:N,CA,C,O,CB
45    NEWMODEL:TYR
    11:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
    NEWMODEL:GLN 12:N,CA,C,O,CB,CG,CD,OE1,NE2
    NEWMODEL:ASP 43:N,CA,C,O,CB,CG,OD1,OD2
    NEWMODEL:TYR
50 44:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
    NEWMODEL:ASN 45:N,CA,C,O,CB,CG,OD1,ND2
    NEWMODEL:HIS 46:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2
    NEWMODEL:ASN 65:N,CA,C,O,CB,CG,OD1,ND2
    NEWMODEL:GLY 87:N,CA,C,O
55    NEWMODEL:ILE 88:N,CA,C,O,CB,CG1,CG2,CD1
    NEWMODEL:GLY 89:N,CA,C,O
    NEWMODEL:LEU 131:N,CA,C,O,CB,CG,CD1,CD2

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  NEWMODEL:PRO 173:N,CA,CD,C,O,CB,CG
  NEWMODEL:ASN 209:N,CA,C,O,CB,CG,OD1,ND2
  NEWMODEL:ALA 211:N,CA,C,O,CB
  NEWMODEL:ASN 216:N,CA,C,O,CB,CG,OD1,ND2
  5  NEWMODEL:ASN 217:N,CA,C,O,CB,CG,OD1,ND2
  NEWMODEL:GLY 218:N,CA,C,O
  NEWMODEL:TYR
  219:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
  NEWMODEL:SER 220:N,CA,C,O,CB,OG
  10 NEWMODEL:TYR
  221:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH
  NEWMODEL:VAL 232:N,CA,C,O,CB,CG1,CG2
  NEWMODEL:ALA 233:N,CA,C,O,CB
  NEWMODEL:GLY 262:N,CA,C,O
  15 NEWMODEL:CA E282H:CA

```

### Example 2

Suitable substitutions in Savinase® for addition of amino  
 20 attachment groups (-NH<sub>2</sub>)

The known X-ray structure of Savinase® was used to find where suitable amino attachment groups may be added (Betzel et al, (1992), J. Mol. Biol. 223, p. 427-445).

The 3D structure of Savinase® is available in the Brookhaven 25 Databank as 1svn.pdb. A related subtilisin is available as 1st3.pdb.

The sequence of Savinase® is shown in SEQ ID NO. 3. The sequence numbering used is that of subtilisin BPN', Savinase® having deletions relative to BPN' at positions: 36, 30 56, 158-159 and 163-164. The active site residues (functional site) are D32,H64 and S221.

The commands performed in Insight (BIOSYM) are shown in the command files makeKzone.bcl and makeKzone2.bcl below:

35 Conservative substitutions:

```

  makeKzone.bcl
  Delete Subset *
  Color Molecule Atoms * Specified Specification 255,0,255
  Zone Subset LYS :lys:NZ Static monomer/residue 10 Color_Subset
  40 255,255,0
  Zone Subset NTERM :e1:N Static monomer/residue 10 Color_Subset
  255,255,0
  #NOTE: editnextline ACTSITE residues according to the protein
  Zone Subset ACTSITE :e32,e64,e221 Static monomer/residue 8
  45 Color_Subset 255,255,0
  Combine Subset ALLZONE Union LYS NTERM
  Combine Subset ALLZONE Union ALLZONE ACTSITE
  #NOTE: editnextline object name according to the protein

```

```

Combine Subset REST Difference SAVI8 ALLZONE
List Subset REST Atom Output_File restatom.list
List Subset REST monomer/residue Output_File restmole.list
Color Molecule Atoms ACTSITE Specified Specification 255,0,0
5 List Subset ACTSITE Atom Output_File actsiteatom.list
List Subset ACTSITE monomer/residue Output_File
actsitemole.list
#
Zone Subset REST5A REST Static Monomer/Residue 5 -Color_Subset
10 Combine Subset SUB5A Difference REST5A ACTSITE
Combine Subset SUB5B Difference SUB5A REST
Color Molecule Atoms SUB5B Specified Specification 255,255,255
List Subset SUB5B Atom Output_File sub5batom.list
List Subset SUB5B monomer/residue Output_File sub5bmole.list
15 #Now identify sites for lys->arg substitutions and continue
with makezone2.bcl
#Use grep command to identify ARG in restatom.list,
sub5batom.list & accsiteatom.list

```

20 Comments:

In this case of Savinase® REST contains the Arginines Arg10, Arg170 and Arg 186, and SUB5B contains Arg19, Arg45, Arg145 and Arg247.

These residues are all solvent exposed. The substitutions 25 R10K, R19K, R45K, R145K, R170K, R186K and R247K are identified in Savinase® as sites for mutagenesis within the scope of this invention. The residues are substituted below in section 2, and further analysis done. The subset ACTSITE contains Lys94.

The substitution K94R is a mutation removing Lysine as 30 attachment group close to the active site.

Non-conservative substitutions:

```

makeKzone2.bcl
#sourcefile makezone2.bcl    Claus von der Osten 961128
35 #
#having scanned lists (grep arg command) and identified sites
for lys->arg substitutions
#NOTE: editnextline object name according to protein
Copy Object -To_Clipboard -Displace SAVI8 newmodel
40 Biopolymer
#NOTE: editnextline object name according to protein
Blank Object On SAVI8
#NOTE: editnextlines with lys->arg positions
Replace Residue newmodel:e10 lys L
45 Replace Residue newmodel:e170 lys L
Replace Residue newmodel:e186 lys L
Replace Residue newmodel:e19 lys L
Replace Residue newmodel:e45 lys L
Replace Residue newmodel:e145 lys L
50 Replace Residue newmodel:e241 lys L

```

```

#
#Now repeat analysis done prior to arg->lys, now including
introduced lysines
Color Molecule Atoms newmodel Specified Specification 255,0,255
5 Zone Subset LYSx newmodel:lys:NZ Static monomer/residue 10
Color Subset 255,255,0
Zone Subset NTERMx newmodel:e1:N Static monomer/residue 10
Color Subset 255,255,0
#NOTE: editnextline ACTSITEx residues according to the protein
10 Zone Subset ACTSITEx newmodel:e32,e64,e221 Static
monomer/residue 8 Color Subset 255,255,0
Combine Subset ALLZONEX Union LYSx NTERMx
Combine Subset ALLZONEX Union ALLZONEX ACTSITEx
Combine Subset RESTx Difference newmodel ALLZONEX
15 List Subset RESTx Atom Output File restxatom.list
List Subset RESTx monomer/residue Output File restxmole.list
#
Color Molecule Atoms ACTSITEx Specified Specification 255,0,0
List Subset ACTSITEx Atom Output File actsitexatom.list
20 List Subset ACTSITEx monomer/residue Output File
actsitexmole.list
#
#read restxatom.list or restxmole.list to identify sites for
(not_arg)->lys subst. if needed
25
Comments:

```

Of the residues in RESTx, the following are >5% exposed (see lists below): 5,14,22,38-40,42,75-76,82,86,103-105,108,133-135,137,140,173,204,206,211-213,215-216,269. The following 30 mutations are proposed in Savinase®: P5K, P14K, T22K, T38K, H39K, P40K, L42K, L75K, N76K, L82K, P86K, S103K, V104K, S105K, A108K, A133K, T134K, L135K, Q137K, N140K, N173K, N204K, Q206K, G211K, S212K, T213K, A215K, S216K, N269K.

Relevant data for Example 2:

```

35 Solvent accessibility data for SAVINASE®:
# SAVI8NOH2O      Fri Nov 29 13:32:07 MET 1996
# residue area
ALA_1      118.362808
GLN_2      49.422764
40 SER_3      61.982887
VAL_4      71.620255
PRO_5      21.737535
TRP_6      58.718731
GLY_7      4.328117
45 ILE_8      6.664074
SER_9      60.175900
ARG_10     70.928963
VAL_11     2.686934
GLN_12     72.839996
50 ALA_13     0.000000
PRO_14     52.308453
ALA_15     38.300892
ALA_16     0.000000

```

HIS_17	41.826324
ASN_18	136.376602
ARG_19	105.678642
GLY_20	48.231510
5 LEU_21	17.196377
THR_22	36.781742
GLY_23	0.000000
SER_24	64.151276
GLY_25	50.269905
10 VAL_26	4.030401
LYS_27	54.239555
VAL_28	0.000000
ALA_29	0.000000
VAL_30	3.572827
15 LEU_31	0.233495
ASP_32	1.074774
THR_33	1.973557
GLY_34	3.638052
ILE_35	8.044439
20 SER_36	8.514903
THR_37	122.598907
HIS_38	18.834011
PRO_39	76.570526
ASP_40	0.000000
25 LEU_41	19.684013
ASN_42	88.870216
ILE_43	56.117710
ARG_44	110.647194
GLY_45	26.935413
30 GLY_46	35.515778
ALA_47	21.495472
SER_48	34.876190
PHE_49	52.647541
VAL_50	23.364208
35 PRO_51	110.408752
GLY_52	80.282906
GLU_53	43.033707
PRO_54	124.444336
SER_55	60.284889
40 THR_56	47.103241
GLN_57	120.803505
ASP_58	12.784743
GLY_59	61.742443
ASN_60	56.760231
45 GLY_61	1.576962
HIS_62	38.590118
GLY_63	0.000000
THR_64	0.537387
HIS_65	0.968253
50 VAL_66	1.612160
ALA_67	0.000000
GLY_68	2.801945
THR_69	9.074596
ILE_70	0.000000
55 ALA_71	4.577205
ALA_72	0.000000
LEU_73	47.290039

ASN_74	102.187248
ASN_75	60.210400
SER_76	84.614494
ILE_77	66.098572
5 GLY_78	17.979534
VAL_79	5.642561
LEU_80	13.025185
GLY_81	0.000000
VAL_82	0.268693
10 ALA_83	0.000000
PRO_84	18.193810
SER_85	56.839039
ALA_86	13.075745
GLU_87	37.011765
15 LEU_88	2.149547
TYR_89	30.633518
ALA_90	1.343467
VAL_91	0.779450
LYS_92	5.862781
20 VAL_93	0.466991
LEU_94	10.747736
GLY_95	8.707102
ALA_96	41.414677
SER_97	96.066040
25 GLY_98	33.374485
SER_99	67.664116
GLY_100	35.571117
SER_101	54.096992
VAL_102	52.695324
30 SER_103	62.929684
SER_104	8.683097
ILE_105	15.852910
ALA_106	14.509443
GLN_107	94.463066
35 GLY_108	0.000000
LEU_109	0.537387
GLU_110	63.227707
TRP_111	55.500740
ALA_112	0.502189
40 GLY_113	11.908267
ASN_114	107.208527
ASN_115	78.811234
GLY_116	41.453194
MET_117	9.634291
45 HIS_118	54.022118
VAL_119	5.105174
ALA_120	0.268693
ASN_121	0.233495
LEU_122	0.537387
50 SER_123	4.004620
LEU_124	21.927265
GLY_125	55.952454
SER_126	40.241180
PRO_127	107.409439
55 SER_128	57.988609
PRO_129	85.021118
SER_130	20.460915

	ALA_131	57.404362
	THR_132	74.438805
	LEU_133	12.091203
	GLU_134	73.382019
5	GLN_135	114.870010
	ALA_136	2.122917
	VAL_137	1.074774
	ASN_138	55.622704
	SER_139	29.174965
10	ALA_140	0.268693
	THR_141	27.962946
	SER_142	87.263145
	ARG_143	88.201218
	GLY_144	38.477882
15	VAL_145	2.079151
	LEU_146	13.703363
	VAL_147	2.690253
	VAL_148	1.074774
	ALA_149	0.000000
20	ALA_150	4.356600
	SER_151	0.000000
	GLY_152	12.628590
	ASN_153	84.248703
	SER_154	77.662354
25	GLY_155	25.409861
	ALA_156	38.074570
	GLY_157	40.493744
	SER_158	53.915291
	ILE_159	4.352278
30	SER_160	12.458543
	TYR_161	29.670284
	PRO_162	4.030401
	ALA_163	0.968253
	ARG_164	84.059120
35	TYR_165	28.641129
	ALA_166	68.193314
	ASN_167	61.686481
	ALA_168	0.537387
	MET_169	0.586837
40	ALA_170	0.000000
	VAL_171	0.000000
	GLY_172	0.000000
	ALA_173	0.933982
	THR_174	3.013133
45	ASP_175	34.551376
	GLN_176	96.873039
	ASN_177	98.664368
	ASN_178	41.197159
	ASN_179	60.263512
50	ARG_180	64.416336
	ALA_181	7.254722
	SER_182	91.590881
	PHE_183	52.126518
	SER_184	2.101459
55	GLN_185	15.736279
	TYR_186	44.287792
	GLY_187	5.114592

	ALA_188	69.406563
	GLY_189	36.926083
	LEU_190	16.511177
	ASP_191	7.705349
5	ILE_192	0.268693
	VAL_193	4.299094
	ALA_194	0.000000
	PRO_195	0.806080
	GLY_196	0.000000
10	VAL_197	25.257177
	ASN_198	82.177422
	VAL_199	10.747736
	GLN_200	80.374527
	SER_201	2.008755
15	THR_202	0.000000
	TYR_203	80.679886
	PRO_204	34.632195
	GLY_205	74.536827
	SER_206	74.964920
20	THR_207	57.070065
	TYR_208	82.895500
	ALA_209	22.838940
	SER_210	69.045639
	LEU_211	49.708279
25	ASN_212	86.905457
	GLY_213	2.686934
	THR_214	4.669909
	SER_215	15.225292
	MET_216	7.261287
30	ALA_217	0.000000
	THR_218	0.000000
	PRO_219	0.806080
	HIS_220	2.662697
	VAL_221	0.268693
35	ALA_222	0.000000
	GLY_223	0.000000
	ALA_224	7.206634
	ALA_225	1.039576
	ALA_226	0.268693
40	LEU_227	1.074774
	VAL_228	1.541764
	LYS_229	39.262505
	GLN_230	54.501614
	LYS_231	81.154129
45	ASN_232	30.004124
	PRO_233	91.917931
	SER_234	102.856705
	TRP_235	64.639481
	SER_236	51.797619
50	ASN_237	24.866917
	VAL_238	78.458466
	GLN_239	73.981461
	ILE_240	14.474245
	ARG_241	41.242931
55	ASN_242	64.644814
	HIS_243	50.671440
	LEU_244	5.127482

LYS\_245 48.820000  
ASN\_246 115.264534  
THR\_247 22.205376  
ALA\_248 16.415077  
5 THR\_249 60.503101  
SER\_250 74.511597  
LEU\_251 48.861599  
GLY\_252 39.124340  
SER\_253 49.811481  
10 THR\_254 88.421982  
ASN\_255 72.490181  
LEU\_256 54.835758  
TYR\_257 38.798912  
GLY\_258 3.620916  
15 SER\_259 35.017368  
GLY\_260 0.537387  
LEU\_261 8.598188  
VAL\_262 4.519700  
ASN\_263 16.763659  
20 ALA\_264 3.413124  
GLU\_265 37.942276  
ALA\_266 15.871746  
ALA\_267 3.947115  
THR\_268 2.475746  
25 ARG\_269 176.743362  
ION\_270 0.000000  
ION\_271 5.197493  
Subset REST:  
restmole.list  
30 Subset REST:  
SAVI8:E5-E15,E17-E18,E22,E38-E40,E42-E43,E73-E76,E82-E86,E103-  
E105,  
SAVI8:E108-E109,E111-E112,E115-E116,E122,E128-E144,E149-  
E150,E156-E157,  
35 SAVI8:E160-E162,E165-E168,E170-E171,E173,E180-E188,E190-  
E192,E200,  
SAVI8:E203-E204,E206,E211-E213,E215-E216,E227-E230,E255-  
E259,E261-E262,  
SAVI8:E267-E269  
40 restatom.list  
Subset REST:  
SAVI8:PRO E5:N,CD,CA,CG,CB,C,O  
SAVI8:TRP E6:N,CA,CD2,CE2,NE1,CD1,CG,CE3,CZ3,CH2,CZ2,CB,C,O  
SAVI8:GLY E7:N,CA,C,O  
45 SAVI8:ILE E8:N,CA,CD1,CG1,CB,CG2,C,O  
SAVI8:SER E9:N,CA,OG,CB,C,O  
SAVI8:ARG E10:N,CA,NH2,NH1,CZ,NE,CD,CG,CB,C,O  
SAVI8:VAL E11:N,CA,CG2,CG1,CB,C,O  
SAVI8:GLN E12:N,CA,NE2,OE1,CD,CG,CB,C,O  
50 SAVI8:ALA E13:N,CA,CB,C,O  
SAVI8:PRO E14:N,CD,CA,CG,CB,C,O  
SAVI8:ALA E15:N,CA,CB,C,O  
SAVI8:HIS E17:N,CA,CD2,NE2,CE1,ND1,CG,CB,C,O  
SAVI8:ASN E18:N,CA,ND2,OD1,CG,CB,C,O  
55 SAVI8:THR E22:N,CA,CG2,OG1,CB,C,O  
SAVI8:THR E38:N,CA,CG2,OG1,CB,C,O  
SAVI8:HIS E39:N,CA,CD2,NE2,CE1,ND1,CG,CB,C,O

SAVI8:PRO E40:N,CD,CA,CG,CB,C,O  
 SAVI8:LEU E42:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:ASN E43:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:ALA E73:N,CA,CB,C,O  
 5 SAVI8:ALA E74:N,CA,CB,C,O  
 SAVI8:LEU E75:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:ASN E76:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:LEU E82:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:GLY E83:N,CA,C,O  
 10 SAVI8:VAL E84:N,CA,CG2,CG1,CB,C,O  
 SAVI8:ALA E85:N,CA,CB,C,O  
 SAVI8:PRO E86:N,CD,CA,CG,CB,C,O  
 SAVI8:SER E103:N,CA,OG,CB,C,O  
 SAVI8:VAL E104:N,CA,CG2,CG1,CB,C,O  
 15 SAVI8:SER E105:N,CA,OG,CB,C,O  
 SAVI8:ALA E108:N,CA,CB,C,O  
 SAVI8:GLN E109:N,CA,NE2,OE1,CD,CG,CB,C,O  
 SAVI8:LEU E111:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:GLU E112:N,CA,OE2,OE1,CD,CG,CB,C,O  
 20 SAVI8:GLY E115:N,CA,C,O  
 SAVI8:ASN E116:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:ALA E122:N,CA,CB,C,O  
 SAVI8:SER E128:N,CA,OG,CB,C,O  
 SAVI8:PRO E129:N,CD,CA,CG,CB,C,O  
 25 SAVI8:SER E130:N,CA,OG,CB,C,O  
 SAVI8:PRO E131:N,CD,CA,CG,CB,C,O  
 SAVI8:SER E132:N,CA,OG,CB,C,O  
 SAVI8:ALA E133:N,CA,CB,C,O  
 SAVI8:THR E134:N,CA,CG2,OG1,CB,C,O  
 30 SAVI8:LEU E135:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:GLU E136:N,CA,OE2,OE1,CD,CG,CB,C,O  
 SAVI8:GLN E137:N,CA,NE2,OE1,CD,CG,CB,C,O  
 SAVI8:ALA E138:N,CA,CB,C,O  
 SAVI8:VAL E139:N,CA,CG2,CG1,CB,C,O  
 35 SAVI8:ASN E140:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:SER E141:N,CA,OG,CB,C,O  
 SAVI8:ALA E142:N,CA,CB,C,O  
 SAVI8:THR E143:N,CA,CG2,OG1,CB,C,O  
 SAVI8:SER E144:N,CA,OG,CB,C,O  
 40 SAVI8:VAL E149:N,CA,CG2,CG1,CB,C,O  
 SAVI8:VAL E150:N,CA,CG2,CG1,CB,C,O  
 SAVI8:SER E156:N,CA,OG,CB,C,O  
 SAVI8:GLY E157:N,CA,C,O  
 SAVI8:ALA E160:N,CA,CB,C,O  
 45 SAVI8:GLY E161:N,CA,C,O  
 SAVI8:SER E162:N,CA,OG,CB,C,O  
 SAVI8:ILE E165:N,CA,CD1,CG1,CB,CG2,C,O  
 SAVI8:SER E166:N,CA,OG,CB,C,O  
 SAVI8:TYR E167:N,CA,OH,CZ,CD2,CE2,CE1,CD1,CG,CB,C,O  
 50 SAVI8:PRO E168:N,CD,CA,CG,CB,C,O  
 SAVI8:ARG E170:N,CA,NH2,NH1,CZ,NE,CD,CG,CB,C,O  
 SAVI8:TYR E171:N,CA,OH,CZ,CD2,CE2,CE1,CD1,CG,CB,C,O  
 SAVI8:ASN E173:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:THR E180:N,CA,CG2,OG1,CB,C,O  
 55 SAVI8:ASP E181:N,CA,OD2,OD1,CG,CB,C,O  
 SAVI8:GLN E182:N,CA,NE2,OE1,CD,CG,CB,C,O  
 SAVI8:ASN E183:N,CA,ND2,OD1,CG,CB,C,O

SAVI8:ASN E184:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:ASN E185:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:ARG E186:N,CA,NH2,NH1,CZ,NE,CD,CG,CB,C,O  
 SAVI8:ALA E187:N,CA,CB,C,O  
 5 SAVI8:SER E188:N,CA,OG,CB,C,O  
 SAVI8:SER E190:N,CA,OG,CB,C,O  
 SAVI8:GLN E191:N,CA,NE2,OE1,CD,CG,CB,C,O  
 SAVI8:TYR E192:N,CA,OH,CZ,CD2,CE2,CE1,CD1,CG,CB,C,O  
 SAVI8:ALA E200:N,CA,CB,C,O  
 10 SAVI8:VAL E203:N,CA,CG2,CG1,CB,C,O  
 SAVI8:ASN E204:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:GLN E206:N,CA,NE2,OE1,CD,CG,CB,C,O  
 SAVI8:GLY E211:N,CA,C,O  
 SAVI8:SER E212:N,CA,OG,CB,C,O  
 15 SAVI8:THR E213:N,CA,CG2,OG1,CB,C,O  
 SAVI8:ALA E215:N,CA,CB,C,O  
 SAVI8:SER E216:N,CA,OG,CB,C,O  
 SAVI8:VAL E227:N,CA,CG2,CG1,CB,C,O  
 SAVI8:ALA E228:N,CA,CB,C,O  
 20 SAVI8:GLY E229:N,CA,C,O  
 SAVI8:ALA E230:N,CA,CB,C,O  
 SAVI8:THR E255:N,CA,CG2,OG1,CB,C,O  
 SAVI8:SER E256:N,CA,OG,CB,C,O  
 SAVI8:LEU E257:N,CA,CD2,CD1,CG,CB,C,O  
 25 SAVI8:GLY E258:N,CA,C,O  
 SAVI8:SER E259:N,CA,OG,CB,C,O  
 SAVI8:ASN E261:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:LEU E262:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:LEU E267:N,CA,CD2,CD1,CG,CB,C,O  
 30 SAVI8:VAL E268:N,CA,CG2,CG1,CB,C,O  
 SAVI8:ASN E269:N,CA,ND2,OD1,CG,CB,C,O  
 Subset SUB5B:  
 sub5bmole.list  
 Subset SUB5B:  
 35 SAVI8:E2-E4,E16,E19-E21,E23-E24,E28,E37,E41,E44-E45,  
 E77-E81,E87-E88,  
 SAVI8:E90,E113-E114,E117-E118,E120-E121,E145-  
 E148,E169,E172,E174-E176,  
 SAVI8:E193-E196,E198-E199,E214,E231-  
 40 E234,E236,E243,E247,E250,E253-E254,  
 SAVI8:E260,E263-E266,E270-E273,M276H-M277H  
 sub5batom.list  
 Subset SUB5B:  
 SAVI8:GLN E2:N,CA,NE2,OE1,CD,CG,CB,C,O  
 45 SAVI8:SER E3:N,CA,OG,CB,C,O  
 SAVI8:VAL E4:N,CA,CG2,CG1,CB,C,O  
 SAVI8:ALA E16:N,CA,CB,C,O  
 SAVI8:ARG E19:N,CA,NH2,NH1,CZ,NE,CD,CG,CB,C,O  
 SAVI8:GLY E20:N,CA,C,O  
 50 SAVI8:LEU E21:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:GLY E23:N,CA,C,O  
 SAVI8:SER E24:N,CA,OG,CB,C,O  
 SAVI8:VAL E28:N,CA,CG2,CG1,CB,C,O  
 SAVI8:SER E37:N,CA,OG,CB,C,O  
 55 SAVI8:ASP E41:N,CA,OD2,OD1,CG,CB,C,O  
 SAVI8:ILE E44:N,CA,CD1,CG1,CB,CG2,C,O  
 SAVI8:ARG E45:N,CA,NH2,NH1,CZ,NE,CD,CG,CB,C,O

SAVI8:ASN E77:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:SER E78:N,CA,OG,CB,C,O  
 SAVI8:ILE E79:N,CA,CD1,CG1,CB,CG2,C,O  
 SAVI8:GLY E80:N,CA,C,O  
 5 SAVI8:VAL E81:N,CA,CG2,CG1,CB,C,O  
 SAVI8:SER E87:N,CA,OG,CB,C,O  
 SAVI8:ALA E88:N,CA,CB,C,O  
 SAVI8:LEU E90:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:TRP E113:N,CA,CD2,CE2,NE1,CD1,CG,CE3,CZ3,CH2,CZ2,CB,C,O  
 10 SAVI8:ALA E114:N,CA,CB,C,O  
 SAVI8:ASN E117:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:GLY E118:N,CA,C,O  
 SAVI8:HIS E120:N,CA,CD2,NE2,CE1,ND1,CG,CB,C,O  
 SAVI8:VAL E121:N,CA,CG2,CG1,CB,C,O  
 15 SAVI8:ARG E145:N,CA,NH2,NH1,CZ,NE,CD,CG,CB,C,O  
 SAVI8:GLY E146:N,CA,C,O  
 SAVI8:VAL E147:N,CA,CG2,CG1,CB,C,O  
 SAVI8:LEU E148:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:ALA E169:N,CA,CB,C,O  
 20 SAVI8:ALA E172:N,CA,CB,C,O  
 SAVI8:ALA E174:N,CA,CB,C,O  
 SAVI8:MET E175:N,CA,CE,SD,CG,CB,C,O  
 SAVI8:ALA E176:N,CA,CB,C,O  
 SAVI8:GLY E193:N,CA,C,O  
 25 SAVI8:ALA E194:N,CA,CB,C,O  
 SAVI8:GLY E195:N,CA,C,O  
 SAVI8:LEU E196:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:ILE E198:N,CA,CD1,CG1,CB,CG2,C,O  
 SAVI8:VAL E199:N,CA,CG2,CG1,CB,C,O  
 30 SAVI8:TYR E214:N,CA,OH,CZ,CD2,CE2,CE1,CD1,CG,CB,C,O  
 SAVI8:ALA E231:N,CA,CB,C,O  
 SAVI8:ALA E232:N,CA,CB,C,O  
 SAVI8:LEU E233:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:VAL E234:N,CA,CG2,CG1,CB,C,O  
 35 SAVI8:GLN E236:N,CA,NE2,OE1,CD,CG,CB,C,O  
 SAVI8:ASN E243:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:ARG E247:N,CA,NH2,NH1,CZ,NE,CD,CG,CB,C,O  
 SAVI8:LEU E250:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:THR E253:N,CA,CG2,OG1,CB,C,O  
 40 SAVI8:ALA E254:N,CA,CB,C,O  
 SAVI8:THR E260:N,CA,CG2,OG1,CB,C,O  
 SAVI8:TYR E263:N,CA,OH,CZ,CD2,CE2,CE1,CD1,CG,CB,C,O  
 SAVI8:GLY E264:N,CA,C,O  
 SAVI8:SER E265:N,CA,OG,CB,C,O  
 45 SAVI8:GLY E266:N,CA,C,O  
 SAVI8:ALA E270:N,CA,CB,C,O  
 SAVI8:GLU E271:N,CA,OE2,OE1,CD,CG,CB,C,O  
 SAVI8:ALA E272:N,CA,CB,C,O  
 SAVI8:ALA E273:N,CA,CB,C,O  
 50 SAVI8:ION M276H:CA  
 SAVI8:ION M277H:CA  
 Subset ACTSITE:  
     actsite.mole.list  
 Subset ACTSITE:  
 55 SAVI8:E29-E35,E48-E51,E54,E58-E72,E91-E102,E106-E107,E110,E123-E127,

SAVI8: E151-E155, E177-E179, E189, E201-E202, E205, E207-E210, E217-E226

actsiteatom.list

5 Subset ACTSITE:

SAVI8:ALA E29:N,CA,CB,C,O  
 SAVI8:VAL E30:N,CA,CG2,CG1,CB,C,O  
 SAVI8:LEU E31:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:ASP E32:N,CA,OD2,OD1,CG,CB,C,O  
 10 SAVI8:THR E33:N,CA,CG2,OG1,CB,C,O  
 SAVI8:GLY E34:N,CA,C,O  
 SAVI8:ILE E35:N,CA,CD1,CG1,CB,CG2,C,O  
 SAVI8:ALA E48:N,CA,CB,C,O  
 SAVI8:SER E49:N,CA,OG,CB,C,O  
 15 SAVI8:PHE E50:N,CA,CD2,CE2,CZ,CE1,CD1,CG,CB,C,O  
 SAVI8:VAL E51:N,CA,CG2,CG1,CB,C,O  
 SAVI8:GLU E54:N,CA,OE2,OE1,CD,CG,CB,C,O  
 SAVI8:THR E58:N,CA,CG2,OG1,CB,C,O  
 SAVI8:GLN E59:N,CA,NE2,OE1,CD,CG,CB,C,O  
 20 SAVI8:ASP E60:N,CA,OD2,OD1,CG,CB,C,O  
 SAVI8:GLY E61:N,CA,C,O  
 SAVI8:ASN E62:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:GLY E63:N,CA,C,O  
 SAVI8:HIS E64:N,CA,CD2,NE2,CE1,ND1,CG,CB,C,O  
 25 SAVI8:GLY E65:N,CA,C,O  
 SAVI8:THR E66:N,CA,CG2,OG1,CB,C,O  
 SAVI8:HIS E67:N,CA,CD2,NE2,CE1,ND1,CG,CB,C,O  
 SAVI8:VAL E68:N,CA,CG2,CG1,CB,C,O  
 SAVI8:ALA E69:N,CA,CB,C,O  
 30 SAVI8:GLY E70:N,CA,C,O  
 SAVI8:THR E71:N,CA,CG2,OG1,CB,C,O  
 SAVI8:ILE E72:N,CA,CD1,CG1,CB,CG2,C,O  
 SAVI8:TYR E91:N,CA,OH,CZ,CD2,CE2,CE1,CD1,CG,CB,C,O  
 SAVI8:ALA E92:N,CA,CB,C,O  
 35 SAVI8:VAL E93:N,CA,CG2,CG1,CB,C,O  
 SAVI8:LYS E94:N,CA,NZ,CE,CD,CG,CB,C,O  
 SAVI8:VAL E95:N,CA,CG2,CG1,CB,C,O  
 SAVI8:LEU E96:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:GLY E97:N,CA,C,O  
 40 SAVI8:ALA E98:N,CA,CB,C,O  
 SAVI8:SER E99:N,CA,OG,CB,C,O  
 SAVI8:GLY E100:N,CA,C,O  
 SAVI8:SER E101:N,CA,OG,CB,C,O  
 SAVI8:GLY E102:N,CA,C,O  
 45 SAVI8:SER E106:N,CA,OG,CB,C,O  
 SAVI8:ILE E107:N,CA,CD1,CG1,CB,CG2,C,O  
 SAVI8:GLY E110:N,CA,C,O  
 SAVI8:ASN E123:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:LEU E124:N,CA,CD2,CD1,CG,CB,C,O  
 50 SAVI8:SER E125:N,CA,OG,CB,C,O  
 SAVI8:LEU E126:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:GLY E127:N,CA,C,O  
 SAVI8:ALA E151:N,CA,CB,C,O  
 SAVI8:ALA E152:N,CA,CB,C,O  
 55 SAVI8:SER E153:N,CA,OG,CB,C,O  
 SAVI8:GLY E154:N,CA,C,O  
 SAVI8:ASN E155:N,CA,ND2,OD1,CG,CB,C,O

SAVI8:VAL E177:N,CA,CG2,CG1,CB,C,O  
 SAVI8:GLY E178:N,CA,C,O  
 SAVI8:ALA E179:N,CA,CB,C,O  
 SAVI8:PHE E189:N,CA,CD2,CE2,CZ,CE1,CD1,CG,CB,C,O  
 5 SAVI8:PRO E201:N,CD,CA,CG,CB,C,O  
 SAVI8:GLY E202:N,CA,C,O  
 SAVI8:VAL E205:N,CA,CG2,CG1,CB,C,O  
 SAVI8:SER E207:N,CA,OG,CB,C,O  
 SAVI8:THR E208:N,CA,CG2,OG1,CB,C,O  
 10 SAVI8:TYR E209:N,CA,OH,CZ,CD2,CE2,CE1,CD1,CG,CB,C,O  
 SAVI8:PRO E210:N,CD,CA,CG,CB,C,O  
 SAVI8:LEU E217:N,CA,CD2,CD1,CG,CB,C,O  
 SAVI8:ASN E218:N,CA,ND2,OD1,CG,CB,C,O  
 SAVI8:GLY E219:N,CA,C,O  
 15 SAVI8:THR E220:N,CA,CG2,OG1,CB,C,O  
 SAVI8:SER E221:N,CA,OG,CB,C,O  
 SAVI8:MET E222:N,CA,CE,SD,CG,CB,C,O  
 SAVI8:ALA E223:N,CA,CB,C,O  
 SAVI8:THR E224:N,CA,CG2,OG1,CB,C,O  
 20 SAVI8:PRO E225:N,CD,CA,CG,CB,C,O  
 SAVI8:HIS E226:N,CA,CD2,NE2,CE1,ND1,CG,CB,C,O  
 Subset RESTx:  
 restxmole.list  
 Subset RESTX:  
 25 NEWMODEL:E5,E13-E14,E22,E38-E40,  
       E42,E73-E76,E82-E86,E103-E105,  
   NEWMODEL:E108,E122,E133-E135,E137-E140,  
       E149-E150,E173,E204,E206,  
   NEWMODEL:E211-E213,E215-E216,E227-      E229,  
 30                   E258,E269  
 restxatom.list  
 Subset RESTX:  
 NEWMODEL:PRO E5:N,CD,CA,CG,CB,C,O  
 NEWMODEL:ALA E13:N,CA,CB,C,O  
 35 NEWMODEL:PRO E14:N,CD,CA,CG,CB,C,O  
 NEWMODEL:THR E22:N,CA,CG2,OG1,CB,C,O  
 NEWMODEL:THR E38:N,CA,CG2,OG1,CB,C,O  
 NEWMODEL:HIS E39:N,CA,CD2,NE2,CE1,ND1,CG,CB,C,O  
 NEWMODEL:PRO E40:N,CD,CA,CG,CB,C,O  
 40 NEWMODEL:LEU E42:N,CA,CD2,CD1,CG,CB,C,O  
 NEWMODEL:ALA E73:N,CA,CB,C,O  
 NEWMODEL:ALA E74:N,CA,CB,C,O  
 NEWMODEL:LEU E75:N,CA,CD2,CD1,CG,CB,C,O  
 NEWMODEL:ASN E76:N,CA,ND2,OD1,CG,CB,C,O  
 45 NEWMODEL:LEU E82:N,CA,CD2,CD1,CG,CB,C,O  
 NEWMODEL:GLY E83:N,CA,C,O  
 NEWMODEL:VAL E84:N,CA,CG2,CG1,CB,C,O  
 NEWMODEL:ALA E85:N,CA,CB,C,O  
 NEWMODEL:PRO E86:N,CD,CA,CG,CB,C,O  
 50 NEWMODEL:SER E103:N,CA,OG,CB,C,O  
 NEWMODEL:VAL E104:N,CA,CG2,CG1,CB,C,O  
 NEWMODEL:SER E105:N,CA,OG,CB,C,O  
 NEWMODEL:ALA E108:N,CA,CB,C,O  
 NEWMODEL:ALA E122:N,CA,CB,C,O  
 55 NEWMODEL:ALA E133:N,CA,CB,C,O  
 NEWMODEL:THR E134:N,CA,CG2,OG1,CB,C,O  
 NEWMODEL:LEU E135:N,CA,CD2,CD1,CG,CB,C,O

NEWMODEL:GLN E137:N,CA,NE2,OE1,CD,CG,CB,C,O  
 NEWMODEL:ALA E138:N,CA,CB,C,O  
 NEWMODEL:VAL E139:N,CA,CG2,CG1,CB,C,O  
 NEWMODEL:ASN E140:N,CA,ND2,OD1,CG,CB,C,O  
 5 NEWMODEL:VAL E149:N,CA,CG2,CG1,CB,C,O  
 NEWMODEL:VAL E150:N,CA,CG2,CG1,CB,C,O  
 NEWMODEL:ASN E173:N,CA,ND2,OD1,CG,CB,C,O  
 NEWMODEL:ASN E204:N,CA,ND2,OD1,CG,CB,C,O  
 NEWMODEL:GLN E206:N,CA,NE2,OE1,CD,CG,CB,C,O  
 10 NEWMODEL:GLY E211:N,CA,C,O  
 NEWMODEL:SER E212:N,CA,OG,CB,C,O  
 NEWMODEL:THR E213:N,CA,CG2,OG1,CB,C,O  
 NEWMODEL:ALA E215:N,CA,CB,C,O  
 NEWMODEL:SER E216:N,CA,OG,CB,C,O  
 15 NEWMODEL:VAL E227:N,CA,CG2,CG1,CB,C,O  
 NEWMODEL:ALA E228:N,CA,CB,C,O  
 NEWMODEL:GLY E229:N,CA,C,O  
 NEWMODEL:GLY E258:N,CA,C,O  
 NEWMODEL:ASN E269:N,CA,ND2,OD1,CG,CB,C,O  
 20

**Example 3**

Suitable substitutions in PD498 for addition of carboxylic acid attachment groups (-COOH)

The 3D structure of PD498 was modeled as described in

**Example 1.**

Suitable locations for addition of carboxylic attachment groups (Aspartic acids and Glutamic acids) were found as follows.

The procedure described in Example 1 was followed. The commands performed in Insight (BIOSYM) are shown in the command files `makeDEzone.bcl` and `makeDEzone2.bcl` below:

**Conservative substitutions:**

**makeDEzone.bcl**

Delete Subset \*

35 Color Molecule Atoms \* Specified Specification 255,0,255  
 Zone Subset ASP :asp:od\* Static monomer/residue 10 Color\_Subset  
 255,255,0  
 Zone Subset GLU :glu:oe\* Static monomer/residue 10 Color\_Subset  
 255,255,0  
 40 #NOTE: editnextline C-terminal residue number according to the  
 protein  
 Zone Subset CTERM :280:0 Static monomer/residue 10 Color\_Subset  
 255,255,0  
 #NOTE: editnextline ACTSITE residues according to the protein  
 45 Zone Subset ACTSITE :39,72,226 Static monomer/residue 8  
 Color\_Subset 255,255,0  
 Combine Subset ALLZONE Union ASP GLU  
 Combine Subset ALLZONE Union CTERM  
 Combine Subset ALLZONE Union ACTSITE  
 50 #NOTE: editnextline object name according to the protein  
 Combine Subset REST Difference PD498FINALMODEL ALLZONE

```
List Subset REST Atom Output File restatom.list
List Subset REST monomer/residue Output File restmole.list
Color Molecule Atoms ACTSITE Specified Specification 255,0,0
List Subset ACTSITE Atom Output File actsiteatom.list
5 List Subset ACTSITE monomer/residue Output File
actsiteatom.list
#
Zone Subset REST5A REST Static Monomer/Residue 5 -Color_Subset
Combine Subset SUB5A Difference REST5A ACTSITE
10 Combine Subset SUB5B Difference SUB5A REST
Color Molecule Atoms SUB5B Specified Specification 255,255,255
List Subset SUB5B Atom Output File sub5batom.list
List Subset SUB5B monomer/residue Output File sub5bmole.list
#Now identify sites for asn->asp & gln->glu substitutions and
15 ...
#continue with makezone2.bcl.
#Use grep command to identify asn/gln in restatom.list ...
#sub5batom.list & actsiteatom.list
```

20 Comments:

The subset REST contains Gln33 and Asn245, SUB5B contains Gln12, Gln126, Asn209, Gln242, Asn246, Gln248 and Asn266, all of which are solvent exposed.

The substitutions Q12E or Q12D, Q33E or Q33D, Q126E or 25 Q126D, N209D or N209E, Q242E or Q242D, N245D or N245E, N246D or N246E, Q248E or Q248D and N266D or N266E are identified in PD498 as sites for mutagenesis within the scope of this invention. Residues are substituted below in section 2, and further analysis done:

30

Non-conservative substitutions:

```
makeDEzone2.bcl
#sourcefile makezone2.bcl    Claus von der Osten    961128
#
35 #having scanned lists (grep gln/asn command) and identified
sites for ...
#asn->asp & gln->glu substitutions
#NOTE: editnextline object name according to protein
Copy Object -To_Clipboard -Displace PD498FINALMODEL newmodel
40 Biopolymer
#NOTE: editnextline object name according to protein
Blank Object On PD498FINALMODEL
#NOTE: editnextlines with asn->asp & gln->glu positions
Replace Residue newmodel:33 glu L
45 Replace Residue newmodel:245 asp L
Replace Residue newmodel:12 glu L
Replace Residue newmodel:126 glu L
Replace Residue newmodel:209 asp L
Replace Residue newmodel:242 glu L
50 Replace Residue newmodel:246 asp L
Replace Residue newmodel:248 glu L
```

```
Replace Residue newmodel:266 asp L
#
#Now repeat analysis done prior to asn->asp & gln->glu, ...
#now including introduced asp & glu
5 Color Molecule Atoms newmodel Specified Specification 255,0,255
Zone Subset ASPx newmodel:asp:od* Static monomer/residue 10
Color_Subset 255,255,0
Zone Subset GLUX newmodel:glu:oe* Static monomer/residue 10
Color_Subset 255,255,0
10 #NOTE: editnextline C-terminal residue number according to the
protein
Zone Subset CTERMx newmodel:280:0 Static monomer/residue 10
Color_Subset 255,255,0
#NOTE: editnextline ACTSITEx residues according to the protein
15 Zone Subset ACTSITEx newmodel:39,72,226 Static monomer/residue
8 Color_Subset 255,255,0
Combine Subset ALLZONEx Union ASPx GLUX
Combine Subset ALLZONEx Union ALLZONEx CTERMx
Combine Subset ALLZONEx Union ALLZONEx ACTSITEx
20 Combine Subset RESTx Difference newmodel ALLZONEx
List Subset RESTx Atom Output_File restxatom.list
List Subset RESTx monomer/residue Output_File restxmole.list
#
Color Molecule Atoms ACTSITEx Specified Specification 255,0,0
25 List Subset ACTSITEx Atom Output_File actsitexatom.list
List Subset ACTSITEx monomer/residue Output_File
actsitexmole.list
#
#read restxatom.list or restxmole.list to identify sites for
30 (not_gluasp)->gluasp ...
#subst. if needed
```

Comments:

The subset RESTx contains only two residues: A233 and G234, 35 none of which are solvent exposed. No further mutagenesis is required to obtain complete protection of the surface. However, it may be necessary to remove some of the reactive carboxylic groups in the active site region to ensure access to the active site of PD498. Acidic residues within the subset 40 ACTSITE are: D39, D58, D68 and D106. Of these only the two latter are solvent exposed and D39 is a functional residue. The mutations D68N, D68Q, D106N and D106Q were found suitable according to the present invention.

Relevant data for Example 3:

45 Solvent accessibility data for PD498MODEL: see Example 1 above.

Subset REST:  
restmole.list

Subset REST:  
PD498FINALMODEL:10-11,33-35,54-55,129-130,  
50 221,233-234,236,240,243,  
PD498FINALMODEL:245,262,264-265

## restatom.list

## Subset REST:

PD498FINALMODEL:ALA 10:N,CA,C,O,CB  
 5 PD498FINALMODEL:TYR 11:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 PD498FINALMODEL:GLN 33:N,CA,C,O,CB,CG,CD,OE1,NE2  
 PD498FINALMODEL:THR 34:N,CA,C,O,CB,OG1,CG2  
 PD498FINALMODEL:VAL 35:N,CA,C,O,CB,CG1,CG2  
 PD498FINALMODEL:ILE 54:N,CA,C,O,CB,CG1,CG2,CD1  
 10 PD498FINALMODEL:LYS 55:N,CA,C,O,CB,CG,CD,CE,NZ  
 PD498FINALMODEL:LYS 129:N,CA,C,O,CB,CG,CD,CE,NZ  
 PD498FINALMODEL:VAL 130:N,CA,C,O,CB,CG1,CG2  
 PD498FINALMODEL:TYR 221:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 PD498FINALMODEL:ALA 233:N,CA,C,O,CB  
 15 PD498FINALMODEL:GLY 234:N,CA,C,O  
 PD498FINALMODEL:ALA 236:N,CA,C,O,CB  
 PD498FINALMODEL:ALA 240:N,CA,C,O,CB  
 PD498FINALMODEL:GLY 243:N,CA,C,O  
 PD498FINALMODEL:ASN 245:N,CA,C,O,CB,CG,OD1,ND2  
 20 PD498FINALMODEL:GLY 262:N,CA,C,O  
 PD498FINALMODEL:GLY 264:N,CA,C,O  
 PD498FINALMODEL:THR 265:N,CA,C,O,CB,OG1,CG2  
 Subset SUB5B:  
 sub5bmodel.list  
 25 Subset SUB5B:  
 PD498FINALMODEL:6-9,12-13,31-32,51-53, 56,81,93-94,97-  
 99,122,126-128,  
 PD498FINALMODEL:131,155-157,159,197-199,209,211,219-  
 220,232,235,  
 30 PD498FINALMODEL:237-239,241-242,244,246-249, 253,260-  
 261,263,266-268  
 sub5batom.list  
 Subset SUB5B:  
 PD498FINALMODEL:PRO 6:N,CA,CD,C,O,CB,CG  
 35 PD498FINALMODEL:TYR 7:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 PD498FINALMODEL:TYR 8:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 PD498FINALMODEL:SER 9:N,CA,C,O,CB,OG  
 PD498FINALMODEL:GLN 12:N,CA,C,O,CB,CG,CD,OE1,NE2  
 PD498FINALMODEL:TYR 13:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 40 PD498FINALMODEL:SER 31:N,CA,C,O,CB,OG  
 PD498FINALMODEL:THR 32:N,CA,C,O,CB,OG1,CG2  
 PD498FINALMODEL:ARG 51:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 PD498FINALMODEL:LYS 52:N,CA,C,O,CB,CG,CD,CE,NZ  
 PD498FINALMODEL:VAL 53:N,CA,C,O,CB,CG1,CG2  
 45 PD498FINALMODEL:GLY 56:N,CA,C,O  
 PD498FINALMODEL:ALA 81:N,CA,C,O,CB  
 PD498FINALMODEL:MET 93:N,CA,C,O,CB,CG,SD,CE  
 PD498FINALMODEL:ALA 94:N,CA,C,O,CB  
 PD498FINALMODEL:THR 97:N,CA,C,O,CB,OG1,CG2  
 50 PD498FINALMODEL:LYS 98:N,CA,C,O,CB,CG,CD,CE,NZ  
 PD498FINALMODEL:ILE 99:N,CA,C,O,CB,CG1,CG2,CD1  
 PD498FINALMODEL:TYR 122:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 PD498FINALMODEL:GLN 126:N,CA,C,O,CB,CG,CD,OE1,NE2  
 PD498FINALMODEL:GLY 127:N,CA,C,O  
 55 PD498FINALMODEL:ALA 128:N,CA,C,O,CB  
 PD498FINALMODEL:LEU 131:N,CA,C,O,CB,CG,CD1,CD2  
 PD498FINALMODEL:GLY 155:N,CA,C,O

PD498FINALMODEL:ALA 156:N,CA,C,O,CB  
PD498FINALMODEL:VAL 157:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:VAL 159:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:TYR 197:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
5 PD498FINALMODEL:GLY 198:N,CA,C,O  
PD498FINALMODEL:THR 199:N,CA,C,O,CB,OG1,CG2  
PD498FINALMODEL:ASN 209:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL:ALA 211:N,CA,C,O,CB  
PD498FINALMODEL:TYR 219:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
10 PD498FINALMODEL:SER 220:N,CA,C,O,CB,OG  
PD498FINALMODEL:VAL 232:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:LEU 235:N,CA,C,O,CB,CG,CD1,CD2  
PD498FINALMODEL:ALA 237:N,CA,C,O,CB  
PD498FINALMODEL:LEU 238:N,CA,C,O,CB,CG,CD1,CD2  
15 PD498FINALMODEL:LEU 239:N,CA,C,O,CB,CG,CD1,CD2  
PD498FINALMODEL:SER 241:N,CA,C,O,CB,OG  
PD498FINALMODEL:GLN 242:N,CA,C,O,CB,CG,CD,OE1,NE2  
PD498FINALMODEL:LYS 244:N,CA,C,O,CB,CG,CD,CE,NZ  
PD498FINALMODEL:ASN 246:N,CA,C,O,CB,CG,OD1,ND2  
20 PD498FINALMODEL:VAL 247:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:GLN 248:N,CA,C,O,CB,CG,CD,OE1,NE2  
PD498FINALMODEL:ILE 249:N,CA,C,O,CB,CG1,CG2,CD1  
PD498FINALMODEL:ILE 253:N,CA,C,O,CB,CG1,CG2,CD1  
PD498FINALMODEL:ILE 260:N,CA,C,O,CB,CG1,CG2,CD1  
25 PD498FINALMODEL:SER 261:N,CA,C,O,CB,OG  
PD498FINALMODEL:THR 263:N,CA,C,O,CB,OG1,CG2  
PD498FINALMODEL:ASN 266:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL:PHE 267:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
PD498FINALMODEL:LYS 268:N,CA,C,O,CB,CG,CD,CE,NZ  
30 Subset ACTSITE:  
actsiteatom.list  
Subset ACTSITE:  
PD498FINALMODEL:36-42,57-60,66-80,100-110,  
115-116,119,132-136,160-164,  
35 PD498FINALMODEL:182-184,194,206-207,210,  
212-215,222-231  
actsiteatom.list  
Subset ACTSITE:  
PD498FINALMODEL:ALA 36:N,CA,C,O,CB  
40 PD498FINALMODEL:VAL 37:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:LEU 38:N,CA,C,O,CB,CG,CD1,CD2  
PD498FINALMODEL:ASP 39:N,CA,C,O,CB,CG,OD1,OD2  
PD498FINALMODEL:SER 40:N,CA,C,O,CB,OG  
PD498FINALMODEL:GLY 41:N,CA,C,O  
45 PD498FINALMODEL:VAL 42:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:TYR  
57:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
PD498FINALMODEL:ASP 58:N,CA,C,O,CB,CG,OD1,OD2  
PD498FINALMODEL:PHE  
50 59:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
PD498FINALMODEL:ILE 60:N,CA,C,O,CB,CG1,CG2,CD1  
PD498FINALMODEL:PRO 66:N,CA,CD,C,O,CB,CG  
PD498FINALMODEL:MET 67:N,CA,C,O,CB,CG,SD,CE  
PD498FINALMODEL:ASP 68:N,CA,C,O,CB,CG,OD1,OD2  
55 PD498FINALMODEL:LEU 69:N,CA,C,O,CB,CG,CD1,CD2  
PD498FINALMODEL:ASN 70:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL:GLY 71:N,CA,C,O

PD498FINALMODEL:HIS 72:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
PD498FINALMODEL:GLY 73:N,CA,C,O  
PD498FINALMODEL:THR 74:N,CA,C,O,CB,OG1,CG2  
PD498FINALMODEL:HIS 75:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
5 PD498FINALMODEL:VAL 76:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:ALA 77:N,CA,C,O,CB  
PD498FINALMODEL:GLY 78:N,CA,C,O  
PD498FINALMODEL:THR 79:N,CA,C,O,CB,OG1,CG2  
PD498FINALMODEL:VAL 80:N,CA,C,O,CB,CG1,CG2  
10 PD498FINALMODEL:LEU 100:N,CA,C,O,CB,CG,CD1,CD2  
PD498FINALMODEL:ALA 101:N,CA,C,O,CB  
PD498FINALMODEL:VAL 102:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:ARG 103:N,CA,C,O,CB,  
CG,CD,NE,CZ,NH1,NH2  
15 PD498FINALMODEL:VAL 104:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:LEU 105:N,CA,C,O,CB,CG,CD1,CD2  
PD498FINALMODEL:ASP 106:N,CA,C,O,CB,CG,OD1,OD2  
PD498FINALMODEL:ALA 107:N,CA,C,O,CB  
PD498FINALMODEL:ASN 108:N,CA,C,O,CB,CG,OD1,ND2  
20 PD498FINALMODEL:GLY 109:N,CA,C,O  
PD498FINALMODEL:SER 110:N,CA,C,O,CB,OG  
PD498FINALMODEL:SER 115:N,CA,C,O,CB,OG  
PD498FINALMODEL:ILE 116:N,CA,C,O,CB,  
CG1,CG2,CD1  
25 PD498FINALMODEL:GLY 119:N,CA,C,O  
PD498FINALMODEL:ASN 132:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL:LEU 133:N,CA,C,O,CB,CG,CD1,CD2  
PD498FINALMODEL:SER 134:N,CA,C,O,CB,OG  
PD498FINALMODEL:LEU 135:N,CA,C,O,CB,CG,CD1,CD2  
30 PD498FINALMODEL:GLY 136:N,CA,C,O  
PD498FINALMODEL:ALA 160:N,CA,C,O,CB  
PD498FINALMODEL:ALA 161:N,CA,C,O,CB  
PD498FINALMODEL:ALA 162:N,CA,C,O,CB  
PD498FINALMODEL:GLY 163:N,CA,C,O  
35 PD498FINALMODEL:ASN 164:N,CA,C,O,CB,CG,OD1,ND2  
PD498FINALMODEL:VAL 182:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:GLY 183:N,CA,C,O  
PD498FINALMODEL:ALA 184:N,CA,C,O,CB  
PD498FINALMODEL:PHE 194:N,CA,C,O,CB,  
40 CG,CD1,CD2,CE1,CE2,CZ  
PD498FINALMODEL:PRO 206:N,CA,CD,C,O,CB,CG  
PD498FINALMODEL:GLY 207:N,CA,C,O  
PD498FINALMODEL:ILE 210:N,CA,C,O,CB,  
CG1,CG2,CD1  
45 PD498FINALMODEL:SER 212:N,CA,C,O,CB,OG  
PD498FINALMODEL:THR 213:N,CA,C,O,CB,OG1,CG2  
PD498FINALMODEL:VAL 214:N,CA,C,O,CB,CG1,CG2  
PD498FINALMODEL:PRO 215:N,CA,CD,C,O,CB,CG  
PD498FINALMODEL:MET 222:N,CA,C,O,CB,CG,SD,CE  
50 PD498FINALMODEL:SER 223:N,CA,C,O,CB,OG  
PD498FINALMODEL:GLY 224:N,CA,C,O  
PD498FINALMODEL:THR 225:N,CA,C,O,CB,OG1,CG2  
PD498FINALMODEL:SER 226:N,CA,C,O,CB,OG  
PD498FINALMODEL:MET 227:N,CA,C,O,CB,CG,SD,CE  
55 PD498FINALMODEL:ALA 228:N,CA,C,O,CB  
PD498FINALMODEL:SER 229:N,CA,C,O,CB,OG  
PD498FINALMODEL:PRO 230:N,CA,CD,C,O,CB,CG

```
PD498FINALMODEL:HIS 231:N,CA,C,O,CB,  
CG,ND1,CD2,CE1,NE2  
Subset RESTx:  
  restxmole.list  
5  Subset RESTX:  
  NEWMODEL:233-234  
  restxatom.list  
Subset RESTX:  
  NEWMODEL:ALA 233:N,CA,C,O,CB  
10  NEWMODEL:GLY 234:N,CA,C,O
```

**Example 4**

Suitable substitutions in the *Arthromyces ramosus* peroxidase  
for addition of carboxylic acid attachment groups (-COOH)

15 Suitable locations for addition of carboxylic attachment  
groups (Aspartic acids and Glutamic acids) in a non-  
hydrolytic enzyme, *Arthromyces ramosus* peroxidase were found as  
follows.

The 3D structure of this oxido-reductase is available in the  
20 Brookhaven Databank as 1arp.pdb. This *A. ramosus* peroxidase  
contains 344 amino acid residues. The first eight residues are  
not visible in the X-ray structure: QGPAGGGGG, and N143 is  
glycosylated.

The procedure described in Example 1 was followed.  
25 The amino acid sequence of *Arthromyces ramosus* Peroxidase  
(E.C.1.11.1.7) is shown in SEQ ID NO 4.

The commands performed in Insight (BIOSYM) are shown in the  
command files makeDEzone.bcl and makeDEzone2.bcl below. The C-  
terminal residue is P344, the ACTSITE is defined as the heme  
30 group and the two histidines coordinating it (H56 & H184).

Conservative substitutions:

```
makeDEzone.bcl  
Delete Subset *  
Color Molecule Atoms * Specified Specification 255,0,255  
35 Zone Subset ASP :asp:od* Static monomer/residue 10 Color_Subset  
255,255,0  
Zone Subset GLU :glu:oe* Static monomer/residue 10 Color_Subset  
255,255,0  
#NOTE: editnextline C-terminal residue number according to the  
40 protein  
Zone Subset CTERM :344:0 Static monomer/residue 10 Color_Subset  
255,255,0  
#NOTE: editnextline ACTSITE residues according to the protein  
Zone Subset ACTSITE :HEM,56,184 Static monomer/residue 8  
45 Color_Subset 255,255,0  
Combine Subset ALLZONE Union ASP GLU  
Combine Subset ALLZONE Union ALLZONE CTERM
```

```

Combine Subset ALLZONE Union ALLZONE ACTSITE
#NOTE: editnextline object name according to the protein
Combine Subset REST Difference ARP ALLZONE
List Subset REST Atom Output_File restatom.list
5 List Subset REST monomer/residue Output_File restmole.list
Color Molecule Atoms ACTSITE Specified Specification 255,0,0
List Subset ACTSITE Atom Output_File actsiteatom.list
List Subset ACTSITE monomer/residue Output_File
actsite mole.list
10 #
Zone Subset REST5A REST Static Monomer/Residue 5 -Color_Subset
Combine Subset SUB5A Difference REST5A ACTSITE
Combine Subset SUB5B Difference SUB5A REST
Color Molecule Atoms SUB5B Specified Specification 255,255,255
15 List Subset SUB5B Atom Output_File sub5batom.list
List Subset SUB5B monomer/residue Output_File sub5bmole.list
#Now identify sites for asn->asp & gln->glu substitutions and
...
#continue with makezone2.bcl.
20 #Use grep command to identify asn/gln in restatom.list ...
#sub5batom.list & accsiteatom.list

```

Comments:

The subset REST contains Gln70, and SUB5B contains Gln34,  
25 Asn128, Asn303 all of which are solvent exposed. The  
substitutions Q34E or Q34D, Q70E or Q70D, N128D or N128E and  
N303D or N303E are identified in *A. ramosus* peroxidase as sites  
for mutagenesis. Residues are substituted below and further  
analysis done:

30

Non-conservative substitutions:

**makeDEzone2.bcl**

```

#sourcefile makezone2.bcl    Claus von der Osten    961128
#
35 #having scanned lists (grep gln/asn command) and identified
sites for ...
#asn->asp & gln->glu substitutions
#NOTE: editnextline object name according to protein
Copy Object -To_Clipboard -Displace ARP newmodel
40 Biopolymer
#NOTE: editnextline object name according to protein
Blank Object On ARP
#NOTE: editnextlines with asn->asp & gln->glu positions
Replace Residue newmodel:34 glu L
45 Replace Residue newmodel:70 glu L
Replace Residue newmodel:128 asp L
Replace Residue newmodel:303 asp L
#
#Now repeat analysis done prior to asn->asp & gln->glu, ...
50 #now including introduced asp & glu
Color Molecule Atoms newmodel Specified Specification 255,0,255

```

```
Zone Subset ASPx newmodel:asp:od* Static monomer/residue 10
Color_Subset 255,255,0
Zone Subset GLUX newmodel:glu:oe* Static monomer/residue 10
Color_Subset 255,255,0
5 #NOTE: editnextline C-terminal residue number according to the
protein
Zone Subset CTERMx newmodel:344:0 Static monomer/residue 10
Color_Subset 255,255,0
#NOTE: editnextline ACTSITEx residues according to the protein
10 Zone Subset ACTSITEx newmodel:HEM,56,184 Static monomer/residue
8 Color_Subset 255,255,0
Combine Subset ALLZONEX Union ASPx GLUX
Combine Subset ALLZONEX Union ALLZONEX CTERMx
Combine Subset ALLZONEX Union ALLZONEX ACTSITEx
15 Combine Subset RESTx Difference newmodel ALLZONEX
List Subset RESTx Atom Output_File restxatom.list
List Subset RESTx monomer/residue Output_File restxmole.list
#
Color Molecule Atoms ACTSITEx Specified Specification 255,0,0
20 List Subset ACTSITEx Atom Output_File actsitexatom.list
List Subset ACTSITEx monomer/residue Output_File
actsitexmole.list
#
#read restxatom.list or restxmole.list to identify sites for
25 (not_gluasp)->gluasp ...
#subst. if needed
```

Comments:

The subset RESTx contains only four residues: S9, S334, G335  
30 and P336, all of which are >5% solvent exposed. The mutations  
S9D, S9E, S334D, S334E, G335D, G335E, P336D and P336E are  
proposed in *A. ramosus* peroxidase. Acidic residues within the  
subset ACTSITE are: E44, D57, D77, E87, E176, D179, E190, D202,  
D209, D246 and the N-terminal carboxylic acid on P344. Of these  
35 only E44, D77, E176, D179, E190, D209, D246 and the N-terminal  
carboxylic acid on P344 are solvent exposed. Suitable sites for  
mutations are E44Q, D77N, E176Q, D179N, E190Q, D209N and D246N.  
D246N and D246E are risky mutations due to D246's importance  
for binding of heme.

40 The N-terminal 8 residues were not included in the  
calculations above, as they do not appear in the structure.  
None of these 8 residues, QGPGGGG, contain carboxylic groups.  
The following variants are proposed as possible mutations to  
enable attachment to this region: Q1E, Q1D, G2E, G2D, P3E, P3D,  
45 G4E, G4D, G5E, G5D, G6E, G6D, G7E, G7D, G8E, G8D.

Relevant data for Example 4:

Solvent accessibility data for *A. ramosus* peroxidase (Note: as the first eight residues are missing in the X-ray structure, the residue numbers printed in the accessibility list below are 8 lower than those used elsewhere for residue numbering.

5 # ARP Thu Jan 30 15:39:05 MET 1997  
# residue area  
SER\_1 143.698257  
VAL\_2 54.879990  
THR\_3 86.932701  
10 CYS\_4 8.303715  
PRO\_5 126.854782  
GLY\_6 53.771488  
GLY\_7 48.137802  
GLN\_8 62.288475  
15 SER\_9 79.932549  
THR\_10 16.299215  
SER\_11 81.928642  
ASN\_12 51.432678  
SER\_13 81.993019  
20 GLN\_14 92.344009  
CYS\_15 0.000000  
CYS\_16 32.317432  
VAL\_17 54.067810  
TRP\_18 6.451035  
25 PHE\_19 25.852070  
ASP\_20 79.033997  
VAL\_21 0.268693  
LEU\_22 22.032858  
ASP\_23 90.111404  
30 ASP\_24 43.993240  
LEU\_25 1.074774  
GLN\_26 25.589321  
THR\_27 82.698059  
ASN\_28 96.600883  
35 PHE\_29 32.375275  
TYR\_30 5.898365  
GLN\_31 103.380585  
GLY\_32 40.042034  
SER\_33 46.789322  
40 LYS\_34 87.161873  
CYS\_35 12.827215  
GLU\_36 51.582657  
SER\_37 16.378180  
PRO\_38 33.560043  
45 VAL\_39 6.448641  
ARG\_40 7.068311  
LYS\_41 15.291286  
ILE\_42 1.612160  
LEU\_43 1.880854  
50 ARG\_44 16.906845  
ILE\_45 0.000000  
VAL\_46 2.312647  
PHE\_47 2.955627  
HIS\_48 20.392527  
55 ASP\_49 4.238116

	ALA_50	0.510757
	ILE_51	1.576962
	GLY_52	2.858601
	PHE_53	48.633503
5	SER_54	8.973248
	PRO_55	58.822315
	ALA_56	59.782852
	LEU_57	46.483955
	THR_58	86.744827
10	ALA_59	89.515816
	ALA_60	81.163239
	GLY_61	70.119019
	GLN_62	112.635498
	PHE_63	93.522354
15	GLY_64	2.742587
	GLY_65	13.379636
	GLY_66	22.722847
	GLY_67	0.000000
	ALA_68	0.268693
20	ASP_69	12.074840
	GLY_70	0.700486
	SER_71	0.000000
	ILE_72	0.000000
	ILE_73	0.000000
25	ALA_74	17.304443
	HIS_75	41.071186
	SER_76	20.000793
	ASN_77	120.855316
	ILE_78	66.574982
30	GLU_79	2.334954
	LEU_80	41.329689
	ALA_81	77.370575
	PHE_82	38.758774
	PRO_83	131.946289
35	ALA_84	34.893864
	ASN_85	5.457000
	GLY_86	43.364151
	GLY_87	51.561348
	LEU_88	0.242063
40	THR_89	73.343575
	ASP_90	130.139389
	THR_91	17.863211
	ILE_92	0.268693
	GLU_93	92.210396
45	ALA_94	35.445068
	LEU_95	1.343467
	ARG_96	31.175611
	ALA_97	44.650192
	VAL_98	17.698566
50	GLY_99	1.471369
	ILE_100	62.441463
	ASN_101	107.139748
	HIS_102	46.952496
	GLY_103	46.559296
55	VAL_104	11.342628
	SER_105	15.225677
	PHE_106	6.422011

	GLY_107	3.426864
	ASP_108	10.740790
	LEU_109	0.268693
	ILE_110	1.880854
5	GLN_111	31.867456
	PHE_112	0.000000
	ALA_113	0.000000
	THR_114	3.656114
	ALA_115	8.299393
10	VAL_116	0.268693
	GLY_117	0.268693
	MET_118	3.761708
	SER_119	14.536770
	ASN_120	25.928799
15	CYS_121	0.537387
	PRO_122	29.798336
	GLY_123	33.080013
	SER_124	17.115562
	PRO_125	36.908714
20	ARG_126	108.274727
	LEU_127	21.238588
	GLU_128	53.742313
	PHE_129	3.761708
	LEU_130	12.928699
25	THR_131	10.414591
	GLY_132	47.266495
	ARG_133	12.247048
	SER_134	63.047237
	ASN_135	31.403708
30	SER_136	97.999619
	SER_137	28.505201
	GLN_138	102.845520
	PRO_139	49.691917
	SER_140	9.423104
35	PRO_141	25.724171
	PRO_142	80.706665
	SER_143	105.318176
	LEU_144	20.154398
	ILE_145	41.288322
40	PRO_146	10.462679
	GLY_147	19.803421
	PRO_148	18.130360
	GLY_149	47.391853
	ASN_150	60.248917
45	THR_151	87.887985
	VAL_152	13.870322
	THR_153	74.664734
	ALA_154	45.251106
	ILE_155	2.686934
50	LEU_156	28.720940
	ASP_157	110.081253
	ARG_158	31.228874
	MET_159	1.612160
	GLY_160	38.223858
55	ASP_161	46.293152
	ALA_162	9.877204
	GLY_163	34.267326

	PHE_164	11.057570
	SER_165	51.158882
	PRO_166	62.767738
	ASP_167	75.164917
5	GLU_168	43.334976
	VAL_169	6.365355
	VAL_170	2.955627
	ASP_171	7.004863
	LEU_172	1.880854
10	LEU_173	3.197691
	ALA_174	0.000000
	ALA_175	1.074774
	HIS_176	0.502189
	SER_177	0.806080
15	LEU_178	3.197691
	ALA_179	3.337480
	SER_180	0.466991
	GLN_181	2.122917
	GLU_182	40.996552
20	GLY_183	62.098671
	LEU_184	23.954853
	ASN_185	15.918136
	SER_186	95.185318
	ALA_187	59.075272
25	ILE_188	27.675419
	PHE_189	102.799423
	ARG_190	55.265549
	SER_191	6.986028
	PRO_192	2.686934
30	LEU_193	12.321225
	ASP_194	2.127163
	SER_195	33.556419
	THR_196	33.049286
	PRO_197	20.874798
35	GLN_198	65.729698
	VAL_199	31.705818
	PHE_200	4.753195
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	THR_202	1.612160
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	PHE_204	2.581340
	TYR_205	1.880854
	ILE_206	9.356181
	GLU_207	0.735684
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	LEU_209	9.672962
	LEU_210	2.955627
	LYS_211	77.176834
	GLY_212	40.968609
50	THR_213	78.718216
	THR_214	21.738384
	GLN_215	77.622299
	PRO_216	25.441587
	GLY_217	8.320850
55	PRO_218	96.972305
	SER_219	64.627823
	LEU_220	85.732414

	GLY_221	27.361111
	PHE_222	134.620178
	ALA_223	3.873014
	GLU_224	12.141763
5	GLU_225	65.129868
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	SER_227	0.268693
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	PHE_229	0.000000
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	GLU_232	6.643466
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	ARG_236	91.415581
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	ALA_239	12.897283
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	LEU_241	3.224321
	ALA_242	1.400973
	ARG_243	77.207176
	ASP_244	36.207306
25	SER_245	104.023796
	ARG_246	121.852341
	THR_247	2.955627
	ALA_248	4.810700
	CYS_249	47.331306
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	SER_253	38.284832
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	SER_257	37.276134
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	MET_272	3.959508
	SER_273	15.043281
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	PHE_277	68.062485

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	VAL_300	45.409184
	ILE_301	8.060802
25	PRO_302	14.742939
	GLY_303	16.589832
	GLY_304	34.238071
	LEU_305	24.719791
	THR_306	49.356300
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	ASP_309	31.733070
	ILE_310	19.581894
	GLU_311	81.414574
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	SER_313	39.688896
	CYS_314	9.998511
	PRO_315	120.328018
	SER_316	95.364319
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	PRO_318	100.254364
	PHE_319	46.284115
	PRO_320	31.328060
	GLU_321	177.602249
45	ILE_322	33.449741
	ALA_323	46.892982
	THR_324	79.976471
	ALA_325	36.423820
	SER_326	124.467422
50	GLY_327	28.219524
	PRO_328	107.553696
	LEU_329	86.789825
	PRO_330	34.287163
	SER_331	75.764053
55	LEU_332	32.840569
	ALA_333	61.516434
	PRO_334	82.389992

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 HEM\_337 60.435017  
 CA\_338 2.078997  
 5 CA\_339 0.000000  
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     ARP:SER 127:N,CA,C,O,CB,OG  
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     ARP:VAL 301:N,CA,C,O,CB,CG1,CG2  
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     ARP:GLN 34:N,CA,C,O,CB,CG,CD,OE1,NE2  
     ARP:TYR 38:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
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     ARP:THR 66:N,CA,C,O,CB,OG1,CG2  
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     ARP:GLY 72:N,CA,C,O  
     ARP:PHE 120:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 45     ARP:ALA 121:N,CA,C,O,CB  
     ARP:ALA 123:N,CA,C,O,CB  
     ARP:VAL 124:N,CA,C,O,CB,CG1,CG2  
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     ARP:CYS 129:N,CA,C,O,CB,SG  
 50     ARP:PRO 130:N,CA,CD,C,O,CB,CG  
     ARP:GLY 131:N,CA,C,O  
     ARP:SER 132:N,CA,C,O,CB,OG  
     ARP:ARG 134:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
     ARP:GLY 270:N,CA,C,O  
 55     ARP:ARG 274:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
     ARP:ILE 297:N,CA,C,O,CB,CG1,CG2,CD1  
     ARP:PRO 298:N,CA,CD,C,O,CB,CG

5           ARP:SER 302:N,CA,C,O,CB,OG  
 ARP:ASN 303:N,CA,C,O,CB,CG,OD1,ND2  
 ARP:GLY 311:N,CA,C,O  
 ARP:GLY 312:N,CA,C,O  
 ARP:THR 332:N,CA,C,O,CB,OG1,CG2  
 ARP:ALA 333:N,CA,C,O,CB  
 ARP:LEU 337:N,CA,C,O,CB,CG,CD1,CD2  
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 ARP:VAL 47:N,CA,C,O,CB,CG1,CG2  
 ARP:ARG 48:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 ARP:LYS 49:N,CA,C,O,CB,CG,CD,CE,NZ  
 25        ARP:ILE 50:N,CA,C,O,CB,CG1,CG2,CD1  
 ARP:LEU 51:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:ARG 52:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 ARP:ILE 53:N,CA,C,O,CB,CG1,CG2,CD1  
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 ARP:ILE 59:N,CA,C,O,CB,CG1,CG2,CD1  
 35        ARP:GLY 60:N,CA,C,O  
 ARP:PHE 61:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 ARP:GLY 75:N,CA,C,O  
 ARP:ALA 76:N,CA,C,O,CB  
 ARP:ASP 77:N,CA,C,O,CB,CG,OD1,OD2  
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 ARP:ILE 80:N,CA,C,O,CB,CG1,CG2,CD1  
 ARP:GLU 87:N,CA,C,O,CB,CG,CD,OE1,OE2  
 ARP:LEU 88:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:PHE 90:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 45        ARP:PRO 91:N,CA,CD,C,O,CB,CG  
 ARP:ALA 92:N,CA,C,O,CB  
 ARP:ASN 93:N,CA,C,O,CB,CG,OD1,ND2  
 ARP:GLY 94:N,CA,C,O  
 ARP:GLY 95:N,CA,C,O  
 50        ARP:LEU 96:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:THR 99:N,CA,C,O,CB,OG1,CG2  
 ARP:ILE 118:N,CA,C,O,CB,CG1,CG2,CD1  
 ARP:THR 122:N,CA,C,O,CB,OG1,CG2  
 ARP:MET 126:N,CA,C,O,CB,CG,SD,CE  
 55        ARP:LEU 135:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:SER 148:N,CA,C,O,CB,OG  
 ARP:PRO 149:N,CA,CD,C,O,CB,CG

ARP:LEU 152:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:ILE 153:N,CA,C,O,CB,CG1,CG2,CD1  
 ARP:PRO 154:N,CA,CD,C,O,CB,CG  
 ARP:GLY 155:N,CA,C,O  
 5 ARP:PRO 156:N,CA,CD,C,O,CB,CG  
 ARP:GLY 157:N,CA,C,O  
 ARP:ASN 158:N,CA,C,O,CB,CG,OD1,ND2  
 ARP:ILE 163:N,CA,C,O,CB,CG1,CG2,CD1  
 ARP:LEU 164:N,CA,C,O,CB,CG,CD1,CD2  
 10 ARP:MET 167:N,CA,C,O,CB,CG,SD,CE  
 ARP:GLU 176:N,CA,C,O,CB,CG,CD,OE1,OE2  
 ARP:VAL 177:N,CA,C,O,CB,CG1,CG2  
 ARP:VAL 178:N,CA,C,O,CB,CG1,CG2  
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 ARP:ALA 183:N,CA,C,O,CB  
 ARP:HIS 184:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
 20 ARP:SER 185:N,CA,C,O,CB,OG  
 ARP:LEU 186:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:ALA 187:N,CA,C,O,CB  
 ARP:SER 188:N,CA,C,O,CB,OG  
 ARP:GLN 189:N,CA,C,O,CB,CG,CD,OE1,NE2  
 25 ARP:GLU 190:N,CA,C,O,CB,CG,CD,OE1,OE2  
 ARP:GLY 191:N,CA,C,O  
 ARP:LEU 192:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:ASN 193:N,CA,C,O,CB,CG,OD1,ND2  
 ARP:SER 194:N,CA,C,O,CB,OG  
 30 ARP:PHE 197:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 ARP:ARG 198:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 ARP:SER 199:N,CA,C,O,CB,OG  
 ARP:PRO 200:N,CA,CD,C,O,CB,CG  
 ARP:LEU 201:N,CA,C,O,CB,CG,CD1,CD2  
 35 ARP:ASP 202:N,CA,C,O,CB,CG,OD1,OD2  
 ARP:SER 203:N,CA,C,O,CB,OG  
 ARP:THR 204:N,CA,C,O,CB,OG1,CG2  
 ARP:PRO 205:N,CA,CD,C,O,CB,CG  
 ARP:VAL 207:N,CA,C,O,CB,CG1,CG2  
 40 ARP:PHE 208:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 ARP:ASP 209:N,CA,C,O,CB,CG,OD1,OD2  
 ARP:GLN 211:N,CA,C,O,CB,CG,CD,OE1,NE2  
 ARP:PHE 212:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 ARP:TYR 213:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 45 ARP:THR 216:N,CA,C,O,CB,OG1,CG2  
 ARP:PHE 230:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 ARP:ALA 231:N,CA,C,O,CB  
 ARP:PHE 241:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 ARP:MET 243:N,CA,C,O,CB,CG,SD,CE  
 50 ARP:ARG 244:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 ARP:SER 245:N,CA,C,O,CB,OG  
 ARP:ASP 246:N,CA,C,O,CB,CG,OD1,OD2  
 ARP:LEU 249:N,CA,C,O,CB,CG,CD1,CD2  
 ARP:TRP 259:N,CA,C,O,CB,CG,CD1,  
 55 CD2,NE1,CE2,CE3,CZ2,CZ3,CH2  
 ARP:TYR 273:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 ARP:MET 277:N,CA,C,O,CB,CG,SD,CE

5           ARP:MET 280:N,CA,C,O,CB,CG,SD,CE  
 ARP:ALA 343:N,CA,C,O,CB  
 ARP:PRO 344:N,CA,CD,C,O,OXT,CB,CG  
 ARP:HEM 345H:FE,NA,NB,NC,ND,CHA,CHB,  
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 ARP:HEM 345H:O1A,O2A,C1B,C2B,C3B,C4B,CMB,  
 CAB,CBB,C1C,C2C,C3C,C4C,CMC,CAC,CBC  
 ARP:HEM 345H:C1D,C2D,C3D,C4D,CMD,CAD,CBD,CGD,O1D,O2D  
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 15          restxatom.list  
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           NEWMODEL:SER 334:N,CA,C,O,CB,OG  
           NEWMODEL:GLY 335:N,CA,C,O  
 20          NEWMODEL:PRO 336:N,CA,CD,C,O,CB,CG

**Example 5**

Activation of mPEG 15,000 with N-succinimidyl carbonate

25          mPEG 15,000 was suspended in toluene (4 ml/g of mPEG) 20% was  
 distilled off at normal pressure to dry the reactants  
 azeotropically. Dichloromethane (dry 1 ml/g mPEG) was added when  
 the solution was cooled to 30°C and phosgene in toluene (1.93 M 5  
 mole/mole mPEG) was added and mixture stirred at room temperature  
 30 over night. The mixture was evaporated to dryness and the desired  
 product was obtained as waxy lumps.

After evaporation dichloromethane and toluene (1:2, dry 3  
 ml/g mPEG) was added to re-dissolve the white solid. N-Hydroxy  
 succinimide (2 mole/mole mPEG.) was added as a solid and then  
 35 triethylamine (1.1 mole/mole mPEG). The mixture was stirred for 3  
 hours. initially unclear, then clear and ending with a small  
 precipitate. The mixture was evaporated to dryness and  
 recrystallised from ethyl acetate (10 ml) with warm filtration to  
 remove salts and insoluble traces. The blank liquid was left for  
 40 slow cooling at ambient temperature for 16 hours and then in the  
 refrigerator over night. The white precipitate was filtered and  
 washed with a little cold ethyl acetate and dried to yield 98 %  
 (w/w) . NMR Indicating 80 - 90% activation and 5 o/oo (w/w)  
 HNET<sub>3</sub>Cl. <sup>1</sup>H-NMR for mPEG 15,000 (CDCl<sub>3</sub>) d 1.42 t (I= 4.8 CH<sub>3</sub> i  
 45 HNET<sub>3</sub>Cl), 2.84 s (I= 3.7 succinimide), 3.10 dq (I= 3.4 CH<sub>2</sub> i  
 HNET<sub>3</sub>Cl), 3.38 s (I= 2.7 CH<sub>3</sub> i OMe), 3.40\* dd (I = 4.5 o/oo, <sup>13</sup>C

satellite), 3.64 bs (I = 1364 main peak), 3.89\* dd (I = 4.8 o/oo, <sup>13</sup>C satellite), 4.47 dd (I = 1.8, CH<sub>2</sub> in PEG). No change was seen after storage in a desiccator at 22°C for 4 months.

5 Example 6

Activation of mPEG 5,000 with N-succinimidyl carbonate

Activation of mPEG 5,000 with N-succinimidyl carbonate was performed as described in Example 5.

10 EXAMPLE 7

Construction and expression of PD498 variants:

PD498 site-directed variants were constructed using the "maxi-oligonucleotide-PCR" method described by Sarkar et al., (1990): BioTechniques 8: 404-407.

15 The template plasmid was shuttle vector pPD498 or an analogue of this containing a variant of the PD498 protease gene.

The following PD498 variants were constructed, expressed and purified.

A: R28K

20 B: R62K

C: R169K

D: R28K + R62K

E: R28K + R169K

F: R62K + R169K

25 G: R28K+R69K+R169K

Construction of variants

For introduction of the R28K substitution a synthetic oligonucleotide having the sequence: GGG ATG TAA CCA AGG GAA GCA 30 GCA CTC AAA CG (SEQ ID NO. 7) was used.

A PCR fragment of 769 bp was ligated into the pPD498 plasmid prepared by Bst E II and Bgl II digestion. Positive variants were recognized by StyI digestion and verified by DNA sequencing of the total 769 bp insert.

35 For introduction of the R62K substitution a synthetic oligonucleotide having the sequence:

CGA CTT TAT CGA TAA GGA CAA TAA CCC (SEQ ID NO. 8) was used.

A PCR fragment of 769 bp was ligated into the pPD498 plasmid

prepared by Bst E II and Bgl II digestion. Positive variants were recognized by ClaI digestion and verified by DNA sequencing of the total 769 bp insert.

For introduction of the R169K substitution a synthetic 5 oligonucleotide having the sequence:

CAA TGT ATC CAA AAC GTT CCA ACC AGC (SEQ ID NO. 9) was used.

A PCR fragment of 769 bp was ligated into the pPD498 plasmid prepared by Bst E II and Bgl II digestion. Positive variants were recognized by the absence of a Rsa I restriction site and verified 10 by DNA sequencing of the total 769 bp insert.

For simultaneously introduction of the R28K and the R62K substitutions, synthetic oligonucleotides having the sequence:

GGG ATG TAA CCA AGG GAA GCA GCA CTC AAA CG (SEQ ID NO. 7) and the sequence:

15 CGA CTT TAT CGA TAA GGA CAA TAA CCC (SEQ ID NO. 8) were used simultaneously. A PCR fragment of 769 bp was ligated into the pPD498 plasmid prepared by Bst E II and Bgl II digestion. Positive variants were recognized by StyI and ClaI digestion and verified by DNA sequencing of the total 769 bp insert.

20 For simultaneously introduction of the R28K and the R169K substitutions, synthetic oligonucleotides having the sequence: GGG ATG TAA CCA AGG GAA GCA GCA CTC AAA CG (SEQ ID NO. 8) and the sequence:

CAA TGT ATC CAA AAC GTT CCA ACC AGC (SEQ ID NO. 8) were used 25 simultaneously. A PCR fragment of 769 bp was ligated into the pPD498 plasmid prepared by Bst E II and Bgl II digestion. Positive variants were recognized by StyI digestion and absence of a Rsa I site. The variant was verified by DNA sequencing of the total 769 bp insert.

30 For simultaneously introduction of the R62K and the R169K substitutions, synthetic oligonucleotides having the sequence: CGA CTT TAT CGA TAA GGA CAA TAA CCC (SEQ ID NO. 8) and the sequence: CAA TGT ATC CAA AAC GTT CCA ACC AGC (SEQ ID NO. 9) were used simultaneously. A PCR fragment of 769 bp was ligated into the 35 pPD498 plasmid prepared by Bst E II and Bgl II digestion. Positive variants were recognized by ClaI digestion and absence of a Rsa I site. The variant was verified by DNA sequencing of the total 769 bp insert

For simultaneously introduction of the R28K, the R62K and the R169K substitutions, synthetic oligonucleotides having the sequence:

5 GGG ATG TAA CCA AGG GAA GCA GCA CTC AAA CG (SEQ ID No. 7), the sequence:

CGA CTT TAT CGA TAA GGA CAA TAA CCC (SEQ ID NO. 8) and the sequence:

10 CAA TGT ATC CAA AAC GTT CCA ACC AGC (SEQ ID NO. 9) were used simultaneously. A PCR fragment of 769 bp was ligated into the pPD498 plasmid prepared by Bst E II and Bgl II digestion. Positive variants were recognized by StyI and ClaI digestion and absence of a Rsa I site. The variant was verified by DNA sequencing of the total 769 bp insert.

15 Fermentation, expression and purification of PD498 variants

Vectors hosting the above mentioned PD498 variants were purified from *E. coli* cultures and transformed into *B. subtilis* in which organism the variants were fermented, expressed and purified as described in the "Materials and Methods" section above.

20

**Example 7**

Conjugation of triple substituted PD498 variant with activated mPEG 5,000

25 200 mg of triple substituted PD498 variant (i.e. the R28K+R62K+R169K substituted variant) was incubated in 50 mM NaBorate, pH 10, with 1.8 g of activated mPEG 5,000 with N-succinimidyl carbonate (prepared according to Example 2), in a final volume of 20 ml. The reaction was carried out at ambient temperature using magnetic stirring. Reaction time was 1 hour. The 30 reaction was stopped by adding DMG buffer to a final concentration of 5 mM dimethyl glutarate, 1 mM CaCl<sub>2</sub> and 50 mM borate, pH 5.0.

The molecule weight of the obtained derivative was approximately 120 kDa, corresponding to about 16 moles of mPEG attached per mole enzyme.

35 Compared to the parent enzyme, residual activity was close to 100% towards peptide substrate (succinyl-Ala-Ala-Pro-Phe-p-Nitroanilide).

**Example 8**Allergenicity trials of PD498 variant-SPEG5,000 in guinea pigs

Dunkin Hartley guinea pigs are stimulated with 1.0 µg PD498-SPEG 5,000 and 1.0 µg modified variant PD498-SPEG 5,000 by 5 intratracheal installation.

Sera from immunized Dunkin Hartley guinea pigs are tested during the trail period in a specific IgG<sub>1</sub> ELISA (described above) to elucidate whether the molecules could activate the immune response system giving rise to a specific IgG<sub>1</sub> response indicating 10 an allergenic response.

The IgG<sub>1</sub> levels of Dunkin Hartley guinea pigs during the trail period of 10 weeks are observed.

**Example 9**

15 Suitable substitutions in *Humicola lanuginosa* lipase for addition of amino attachment groups (-NH<sub>2</sub>)

The 3D structure of *Humicola lanuginosa* lipase (SEQ ID NO 6) is available in Brookhaven Databank as 1tib.pdb. The lipase consists of 269 amino acids.

20 The procedure described in Example 1 was followed. The sequence of *H. lanuginosa* lipase is shown below in the table listing solvent accessibility data for *H. lanuginosa* lipase. *H. lanuginosa* residue numbering is used (1-269), and the active site residues (functional site) are S146, S201 and H258. The 25 synonym TIB is used for *H. lanuginosa* lipase.

The commands performed in Insight (BIOSYM) are shown in the command files makeKzone.bcl and makeKzone2.bcl below:

Conservative substitutions:

30 **makeKzone.bcl**  
1 Delete Subset \*  
2 Color Molecule Atoms \* Specified Specification 255,0,255  
3 Zone Subset LYS :lys:NZ Static monomer/residue 10  
Color\_Subset 255,255,0  
35 4 Zone Subset NTERM :1:N Static monomer/residue 10  
Color\_Subset 255,255,0  
5 #NOTE: editnextline ACTSITE residues according to the protein  
6 Zone Subset ACTSITE :146,201,258 Static monomer/residue 8  
40 Color\_Subset 255,255,0  
7 Combine Subset ALLZONE Union LYS NTERM  
8 Combine Subset ALLZONE Union ALLZONE ACTSITE  
9 #NOTE: editnextline object name according to the protein

```

10 Combine Subset REST Difference TIB ALLZONE
11 List Subset REST Atom Output File restatom.list
12 List Subset REST monomer/residue Output File restmole.list
13 Color Molecule Atoms ACTSITE Specified Specification 255,0,0
5 14 List Subset ACTSITE Atom Output File actsiteatom.list
15 List Subset ACTSITE monomer/residue Output File
actsitemole.list
16 #
17 Zone Subset REST5A REST Static Monomer/Residue 5 -
10 Color_Subset
18 Combine Subset SUB5A Difference REST5A ACTSITE
19 Combine Subset SUB5B Difference SUB5A REST
20 Color Molecule Atoms SUB5B Specified Specification
255,255,255
15 21 List Subset SUB5B Atom Output File sub5batom.list
22 List Subset SUB5B monomer/residue Output File sub5bmole.list
23 #Now identify sites for lys->arg substitutions and continue
with makezone2.bcl
24 #Use grep command to identify ARG in restatom.list,
20 sub5batom.list & accsiteatom.list

```

Comments:

In this case of *H. lanuginosa* (=TIB), REST contains the Arginines Arg133, Arg139, Arg160, Arg179 and Arg 209, and SUB5B contains Arg118 and R125.

These residues are all solvent exposed. The substitutions R133K, R139K, R160K, R179K, R209K, R118K and R125K are identified in TIB as sites for mutagenesis within the scope of this invention. The residues are substituted below in section 30 2, and further analysis done. The subset ACTSITE contains no lysines.

Non-conservative substitutions:

**makeKzone2.bcl**

```

35 1  #sourcefile makezone2.bcl  Claus von der Osten  961128
2  #
3  #having scanned lists (grep arg command) and identified
sites for lys->arg substitutions
4  #NOTE: editnextline object name according to protein
40 5  Copy Object -To_Clipboard -Displace TIB newmodel
6  Biopolymer
7  #NOTE: editnextline object name according to protein
8  Blank Object On TIB
9  #NOTE: editnextlines with lys->arg positions
45 10 Replace Residue newmodel:118 lys L
11 Replace Residue newmodel:125 lys L
12 Replace Residue newmodel:133 lys L
13 Replace Residue newmodel:139 lys L
14 Replace Residue newmodel:160 lys L
50 15 Replace Residue newmodel:179 lys L
16 Replace Residue newmodel:209 lys L

```

```

17  #
18  #Now repeat analysis done prior to arg->lys, now including
introduced lysines
19  Color Molecule Atoms newmodel Specified Specification
5  255,0,255
20  Zone Subset LYSx newmodel:lys:NZ Static monomer/residue 10
Color_Subset 255,255,0
21  Zone Subset NTERMx newmodel:1:N Static monomer/residue 10
Color_Subset 255,255,0
10  22  #NOTE: editnextline ACTSITEx residues according to the
protein
23  Zone Subset ACTSITEx newmodel:146,201,258 Static
monomer/residue 8 Color_Subset 255,255,0
24  Combine Subset ALLZONEx Union LYSx NTERMx
15  25  Combine Subset ALLZONEx Union ALLZONEx ACTSITEx
26  Combine Subset RESTx Difference newmodel ALLZONEx
27  List Subset RESTx Atom Output_File restxatom.list
28  List Subset RESTx monomer/residue Output_File
restxmole.list
20  29  #
30  Color Molecule Atoms ACTSITEx Specified Specification
255,0,0
31  List Subset ACTSITEx Atom Output_File actsitexatom.list
32  List Subset ACTSITEx monomer/residue Output_File
25  actsitexmole.list
33  #
34  #read restxatom.list or restxmole.list to identify sites
for (not_arg)->lys subst. if needed

```

30 Comments:

Of the residues in RESTx, the following are >5% exposed (see lists below): 18, 31-33, 36, 38, 40, 48, 50, 56-62, 64, 78, 88, 91-93, 104-106, 120, 136, 225, 227-229, 250, 262, 268. Of these three are Cysteines involved in disulfide bridge formation, and 35 consequently for structural reasons excluded from the residues to be mutated. The following mutations are proposed in *H.*

*lanuginosa* lipase (TIB):

A18K, G31K, T32K, N33K, G38K, A40K, D48K, T50K, E56K, D57K, S58K, G59K,  
 V60K, G61K, D62K, T64K, L78K, N88K, G91K, N92K, L93K, S105K, G106K,  
 40 V120K, P136K, G225K, L227K, V228K, P229K, P250K, F262K.

Relevant data for Example 2:

```

# TIBNOH2O
# residue area
GLU_1 110.792610
45 VAL_2 18.002457
SER_3 53.019516
GLN_4 85.770164
ASP_5 107.565826
LEU_6 33.022659
50 PHE_7 34.392754
ASN_8 84.855331

```

	GLN_9	39.175591
	PHE_10	2.149547
	ASN_11	40.544380
	LEU_12	27.648788
5	PHE_13	2.418241
	ALA_14	4.625293
	GLN_15	28.202387
	TYR_16	0.969180
	SER_17	0.000000
10	ALA_18	7.008336
	ALA_19	0.000000
	ALA_20	0.000000
	TYR_21	6.947358
	CYS_22	8.060802
15	GLY_23	32.147034
	LYS_24	168.890747
	ASN_25	8.014721
	ASN_26	11.815564
	ASP_27	92.263428
20	ALA_28	18.206699
	PRO_29	83.188431
	ALA_30	69.428421
	GLY_31	50.693439
	THR_32	52.171135
25	ASN_33	111.230743
	ILE_34	2.801945
	THR_35	82.130569
	CYS_36	17.269245
	THR_37	96.731941
30	GLY_38	77.870995
	ASN_39	123.051003
	ALA_40	27.985256
	CYS_41	0.752820
	PRO_42	46.258949
35	GLU_43	69.773987
	VAL_44	0.735684
	GLU_45	77.169510
	LYS_46	141.213562
	ALA_47	10.249716
40	ASP_48	109.913902
	ALA_49	2.602721
	THR_50	32.012184
	PHE_51	8.255627
	LEU_52	60.093613
45	TYR_53	77.877937
	SER_54	26.980494
	PHE_55	10.747735
	GLU_56	112.689758
	ASP_57	92.064278
50	SER_58	32.990780
	GLY_59	53.371807
	VAL_60	83.563644
	GLY_61	69.625633
	ASP_62	75.520988
55	VAL_63	4.030401
	THR_64	8.652839
	GLY_65	0.000000

	PHE_66	0.268693
	LEU_67	11.822510
	ALA_68	0.537387
	LEU_69	30.243870
5	ASP_70	0.000000
	ASN_71	84.101044
	THR_72	89.271126
	ASN_73	70.742401
	LYS_74	98.319168
10	LEU_75	8.329495
	ILE_76	5.197878
	VAL_77	0.806080
	LEU_78	5.293978
	SER_79	0.000000
15	PHE_80	2.079151
	ARG_81	41.085312
	GLY_82	1.471369
	SER_83	43.794014
	ARG_84	100.261627
20	SER_85	70.607552
	ILE_86	59.696865
	GLU_87	136.510773
	ASN_88	119.376373
	TRP_89	102.851227
25	ILE_90	78.068588
	GLY_91	60.783607
	ASN_92	45.769428
	LEU_93	134.228363
	ASN_94	101.810959
30	PHE_95	41.212212
	ASP_96	79.645950
	LEU_97	25.281572
	LYS_98	88.840263
	GLU_99	132.377090
35	ILE_100	9.135575
	ASN_101	63.444527
	ASP_102	88.652847
	ILE_103	33.470661
	CYS_104	11.553816
40	SER_105	99.461174
	GLY_106	40.325161
	CYS_107	4.433561
	ARG_108	97.450104
	GLY_109	1.343467
45	HIS_110	4.652464
	ASP_111	37.023655
	GLY_112	29.930408
	PHE_113	14.976435
	THR_114	10.430954
50	SER_115	40.606895
	SER_116	13.462922
	TRP_117	10.747735
	ARG_118	114.364281
	SER_119	46.880249
55	VAL_120	13.434669
	ALA_121	18.258261
	ASP_122	110.753098

	THR_123	69.641922
	LEU_124	17.090784
	ARG_125	73.929977
	GLN_126	101.320190
5	LYS_127	84.450241
	VAL_128	6.448641
	GLU_129	47.700993
	ASP_130	75.529091
	ALA_131	11.340775
10	VAL_132	27.896025
	ARG_133	153.136490
	GLU_134	132.140594
	HIS_135	54.553406
	PRO_136	97.386963
15	ASP_137	22.653191
	TYR_138	35.392658
	ARG_139	74.321243
	VAL_140	10.173222
	VAL_141	0.233495
20	PHE_142	3.224321
	THR_143	0.000000
	GLY_144	0.000000
	HIS_145	4.514527
	SER_146	15.749787
25	LEU_147	40.709171
	GLY_148	0.000000
	GLY_149	0.000000
	ALA_150	0.537387
	LEU_151	22.838938
30	ALA_152	0.268693
	THR_153	18.078798
	VAL_154	7.254722
	ALA_155	0.000000
	GLY_156	0.000000
35	ALA_157	15.140230
	ASP_158	41.645477
	LEU_159	6.144750
	ARG_160	41.939716
	GLY_161	68.978180
40	ASN_162	68.243805
	GLY_163	79.181274
	TYR_164	36.190247
	ASP_165	103.068283
	ILE_166	0.000000
45	ASP_167	24.326443
	VAL_168	4.299094
	PHE_169	0.466991
	SER_170	3.339332
	TYR_171	0.000000
50	GLY_172	0.000000
	ALA_173	12.674671
	PRO_174	13.117888
	ARG_175	10.004488
	VAL_176	21.422220
55	GLY_177	2.680759
	ASN_178	21.018063
	ARG_179	110.282166

	ALA_180	33.210381
	PHE_181	4.567788
	ALA_182	3.897251
	GLU_183	76.354004
5	PHE_184	71.225983
	LEU_185	24.985012
	THR_186	47.023815
	VAL_187	98.244606
	GLN_188	54.152954
10	THR_189	88.660645
	GLY_190	24.792120
	GLY_191	10.726818
	THR_192	45.458744
	LEU_193	16.633211
15	TYR_194	34.829491
	ARG_195	29.030851
	ILE_196	1.973557
	THR_197	3.493014
	HIS_198	1.532270
20	THR_199	34.785877
	ASN_200	39.789238
	ASP_201	0.000000
	ILE_202	31.168434
	VAL_203	29.521076
25	PRO_204	3.515322
	ARG_205	44.882454
	LEU_206	51.051746
	PRO_207	12.575329
	PRO_208	43.259636
30	ARG_209	113.700233
	GLU_210	154.628540
	PHE_211	112.505188
	GLY_212	30.084938
	TYR_213	3.268936
35	SER_214	12.471436
	HIS_215	23.354481
	SER_216	16.406200
	SER_217	14.665598
	PRO_218	17.240993
40	GLU_219	13.145291
	TYR_220	18.718306
	TRP_221	39.229233
	ILE_222	5.105175
	LYS_223	120.739983
45	SER_224	15.407301
	GLY_225	29.306646
	THR_226	66.806862
	LEU_227	122.682808
	VAL_228	60.923004
50	PRO_229	104.620377
	VAL_230	23.398251
	THR_231	63.372971
	ARG_232	80.357857
	ASN_233	89.255066
55	ASP_234	43.011250
	ILE_235	2.114349
	VAL_236	45.140491

LYS\_237 105.651306  
ILE\_238 24.671705  
GLU\_239 116.891907  
GLY\_240 31.965794  
5 ILE\_241 46.278099  
ASP\_242 28.963699  
ALA\_243 25.158146  
THR\_244 98.351440  
GLY\_245 43.842186  
10 GLY\_246 0.700486  
ASN\_247 3.926274  
ASN\_248 51.047890  
GLN\_249 66.699188  
PRO\_250 132.414047  
15 ASN\_251 70.213730  
ILE\_252 141.498062  
PRO\_253 59.089233  
ASP\_254 59.010895  
ILE\_255 63.298943  
20 PRO\_256 78.608688  
ALA\_257 0.806080  
HIS\_258 3.761708  
LEU\_259 50.747856  
TRP\_260 35.229710  
25 TYR\_261 5.440791  
PHE\_262 36.457939  
GLY\_263 22.071375  
LEU\_264 109.148178  
ILE\_265 2.418241  
30 GLY\_266 17.730062  
THR\_267 68.217873  
CYS\_268 15.418195  
LEU\_269 165.990997  
Subset REST:  
35 restmole.list  
Subset REST:  
TIB:5,8-9,13-14,16,18-20,31-34,36,38,40,48-50,56-  
66,68,76-79,88,91-93,  
TIB:100-107,116-117,119-121,132-134,136,139-142,154-  
40 169,177-185,  
TIB:187,189-191,207-212,214-216,225,227-229,241-  
244,250,262,268  
restatom.list  
Subset REST:  
45 TIB:ASP 5:N,CA,C,O,CB,CG,OD1,OD2  
TIB:ASN 8:N,CA,C,O,CB,CG,OD1,ND2  
TIB:GLN 9:N,CA,C,O,CB,CG,CD,OE1,NE2  
TIB:PHE 13:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
TIB:ALA 14:N,CA,C,O,CB  
50 TIB:TYR 16:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
TIB:ALA 18:N,CA,C,O,CB  
TIB:ALA 19:N,CA,C,O,CB  
TIB:ALA 20:N,CA,C,O,CB  
TIB:GLY 31:N,CA,C,O  
55 TIB:THR 32:N,CA,C,O,CB,OG1,CG2  
TIB:ASN 33:N,CA,C,O,CB,CG,OD1,ND2  
TIB:ILE 34:N,CA,C,O,CB,CG1,CG2,CD1

TIB:CYS 36:N,CA,C,O,CB,SG  
TIB:GLY 38:N,CA,C,O  
TIB:ALA 40:N,CA,C,O,CB  
TIB:ASP 48:N,CA,C,O,CB,CG,OD1,OD2  
5 TIB:ALA 49:N,CA,C,O,CB  
TIB:THR 50:N,CA,C,O,CB,OG1,CG2  
TIB:GLU 56:N,CA,C,O,CB,CG,CD,OE1,OE2  
TIB:ASP 57:N,CA,C,O,CB,CG,OD1,OD2  
TIB:SER 58:N,CA,C,O,CB,OG  
10 TIB:GLY 59:N,CA,C,O  
TIB:VAL 60:N,CA,C,O,CB,CG1,CG2  
TIB:GLY 61:N,CA,C,O  
TIB:ASP 62:N,CA,C,O,CB,CG,OD1,OD2  
TIB:VAL 63:N,CA,C,O,CB,CG1,CG2  
15 TIB:THR 64:N,CA,C,O,CB,OG1,CG2  
TIB:GLY 65:N,CA,C,O  
TIB:PHE 66:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
TIB:ALA 68:N,CA,C,O,CB  
TIB:ILE 76:N,CA,C,O,CB,CG1,CG2,CD1  
20 TIB:VAL 77:N,CA,C,O,CB,CG1,CG2  
TIB:LEU 78:N,CA,C,O,CB,CG,CD1,CD2  
TIB:SER 79:N,CA,C,O,CB,OG  
TIB:ASN 88:N,CA,C,O,CB,CG,OD1,ND2  
TIB:GLY 91:N,CA,C,O  
25 TIB:ASN 92:N,CA,C,O,CB,CG,OD1,ND2  
TIB:LEU 93:N,CA,C,O,CB,CG,CD1,CD2  
TIB:ILE 100:N,CA,C,O,CB,CG1,CG2,CD1  
TIB:ASN 101:N,CA,C,O,CB,CG,OD1,ND2  
TIB:ASP 102:N,CA,C,O,CB,CG,OD1,OD2  
30 TIB:ILE 103:N,CA,C,O,CB,CG1,CG2,CD1  
TIB:CYS 104:N,CA,C,O,CB,SG  
TIB:SER 105:N,CA,C,O,CB,OG  
TIB:GLY 106:N,CA,C,O  
TIB:CYS 107:N,CA,C,O,CB,SG  
35 TIB:SER 116:N,CA,C,O,CB,OG  
TIB:TRP 117:N,CA,C,O,CB,CG,CD1,CD2,NE1,CE2,  
CE3,CZ2,CZ3,CH2  
TIB:SER 119:N,CA,C,O,CB,OG  
TIB:VAL 120:N,CA,C,O,CB,CG1,CG2  
40 TIB:ALA 121:N,CA,C,O,CB  
TIB:VAL 132:N,CA,C,O,CB,CG1,CG2  
TIB:ARG 133:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
TIB:GLU 134:N,CA,C,O,CB,CG,CD,OE1,OE2  
TIB:PRO 136:N,CA,CD,C,O,CB,CG  
45 TIB:ARG 139:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
TIB:VAL 140:N,CA,C,O,CB,CG1,CG2  
TIB:VAL 141:N,CA,C,O,CB,CG1,CG2  
TIB:PHE 142:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
TIB:VAL 154:N,CA,C,O,CB,CG1,CG2  
50 TIB:ALA 155:N,CA,C,O,CB  
TIB:GLY 156:N,CA,C,O  
TIB:ALA 157:N,CA,C,O,CB  
TIB:ASP 158:N,CA,C,O,CB,CG,OD1,OD2  
TIB:LEU 159:N,CA,C,O,CB,CG,CD1,CD2  
55 TIB:ARG 160:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
TIB:GLY 161:N,CA,C,O  
TIB:ASN 162:N,CA,C,O,CB,CG,OD1,ND2

TIB:GLY 163:N,CA,C,O  
 TIB:TYR 164:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 TIB:ASP 165:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:ILE 166:N,CA,C,O,CB,CG1,CG2,CD1  
 5 TIB:ASP 167:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:VAL 168:N,CA,C,O,CB,CG1,CG2  
 TIB:PHE 169:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:GLY 177:N,CA,C,O  
 TIB:ASN 178:N,CA,C,O,CB,CG,OD1,ND2  
 10 TIB:ARG 179:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 TIB:ALA 180:N,CA,C,O,CB  
 TIB:PHE 181:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:ALA 182:N,CA,C,O,CB  
 TIB:GLU 183:N,CA,C,O,CB,CG,CD,OE1,OE2  
 15 TIB:PHE 184:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:LEU 185:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:VAL 187:N,CA,C,O,CB,CG1,CG2  
 TIB:THR 189:N,CA,C,O,CB,OG1,CG2  
 TIB:GLY 190:N,CA,C,O  
 20 TIB:GLY 191:N,CA,C,O  
 TIB:PRO 207:N,CA,CD,C,O,CB,CG  
 TIB:PRO 208:N,CA,CD,C,O,CB,CG  
 TIB:ARG 209:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 TIB:GLU 210:N,CA,C,O,CB,CG,CD,OE1,OE2  
 25 TIB:PHE 211:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:GLY 212:N,CA,C,O  
 TIB:SER 214:N,CA,C,O,CB,OG  
 TIB:HIS 215:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
 TIB:SER 216:N,CA,C,O,CB,OG  
 30 TIB:GLY 225:N,CA,C,O  
 TIB:LEU 227:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:VAL 228:N,CA,C,O,CB,CG1,CG2  
 TIB:PRO 229:N,CA,CD,C,O,CB,CG  
 TIB:ILE 241:N,CA,C,O,CB,CG1,CG2,CD1  
 35 TIB:ASP 242:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:ALA 243:N,CA,C,O,CB  
 TIB:THR 244:N,CA,C,O,CB,OG1,CG2  
 TIB:PRO 250:N,CA,CD,C,O,CB,CG  
 TIB:PHE 262:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 40 TIB:CYS 268:N,CA,C,O,CB,SG  
 Subset SUB5B:  
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 Subset SUB5B:  
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 45 55,67,69-70,  
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 131,135,137-138,  
 TIB:186,188,192-195,213,217-219,223-224,230-231,234-235,238-  
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 50 TIB:245,269  
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 TIB:GLN 4:N,CA,C,O,CB,CG,CD,OE1,NE2  
 55 TIB:LEU 6:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:PHE 7:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:PHE 10:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ

TIB:ASN 11:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:LEU 12:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:GLN 15:N,CA,C,O,CB,CG,CD,OE1,NE2  
 TIB:CYS 22:N,CA,C,O,CB,SG  
 5 TIB:GLY 23:N,CA,C,O  
 TIB:ASN 25:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:ASN 26:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:ASP 27:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:ALA 28:N,CA,C,O,CB  
 10 TIB:PRO 29:N,CA,CD,C,O,CB,CG  
 TIB:ALA 30:N,CA,C,O,CB  
 TIB:THR 35:N,CA,C,O,CB,OG1,CG2  
 TIB:THR 37:N,CA,C,O,CB,OG1,CG2  
 TIB:ASN 39:N,CA,C,O,CB,CG,OD1,ND2  
 15 TIB:CYS 41:N,CA,C,O,CB,SG  
 TIB:PRO 42:N,CA,CD,C,O,CB,CG  
 TIB:VAL 44:N,CA,C,O,CB,CG1,CG2  
 TIB:GLU 45:N,CA,C,O,CB,CG,CD,OE1,OE2  
 TIB:LYS 46:N,CA,C,O,CB,CG,CD,CE,NZ  
 20 TIB:ALA 47:N,CA,C,O,CB  
 TIB:PHE 51:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:LEU 52:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:TYR 53:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 TIB:SER 54:N,CA,C,O,CB,OG  
 25 TIB:PHE 55:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:LEU 67:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:LEU 69:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:ASP 70:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:THR 72:N,CA,C,O,CB,OG1,CG2  
 30 TIB:LYS 74:N,CA,C,O,CB,CG,CD,CE,NZ  
 TIB:LEU 75:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:ASN 94:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:PHE 95:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
 TIB:ASP 96:N,CA,C,O,CB,CG,OD1,OD2  
 35 TIB:LEU 97:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:LYS 98:N,CA,C,O,CB,CG,CD,CE,NZ  
 TIB:GLU 99:N,CA,C,O,CB,CG,CD,OE1,OE2  
 TIB:ARG 108:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 TIB:GLY 109:N,CA,C,O  
 40 TIB:HIS 110:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
 TIB:ASP 111:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:GLY 112:N,CA,C,O  
 TIB:THR 114:N,CA,C,O,CB,OG1,CG2  
 TIB:SER 115:N,CA,C,O,CB,OG  
 45 TIB:ARG 118:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 TIB:ASP 122:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:THR 123:N,CA,C,O,CB,OG1,CG2  
 TIB:LEU 124:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:ARG 125:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 50 TIB:GLN 126:N,CA,C,O,CB,CG,CD,OE1,NE2  
 TIB:VAL 128:N,CA,C,O,CB,CG1,CG2  
 TIB:GLU 129:N,CA,C,O,CB,CG,CD,OE1,OE2  
 TIB:ASP 130:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:ALA 131:N,CA,C,O,CB  
 55 TIB:HIS 135:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
 TIB:ASP 137:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:TYR 138:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH

5           TIB:THR 186:N,CA,C,O,CB,OG1,CG2  
          TIB:GLN 188:N,CA,C,O,CB,CG,CD,OE1,NE2  
          TIB:THR 192:N,CA,C,O,CB,OG1,CG2  
          TIB:LEU 193:N,CA,C,O,CB,CG,CD1,CD2  
          TIB:TYR 194:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
          TIB:ARG 195:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
          TIB:TYR 213:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
          TIB:SER 217:N,CA,C,O,CB,OG  
          TIB:PRO 218:N,CA,CD,C,O,CB,CG  
10          TIB:GLU 219:N,CA,C,O,CB,CG,CD,OE1,OE2  
          TIB:LYS 223:N,CA,C,O,CB,CG,CD,CE,NZ  
          TIB:SER 224:N,CA,C,O,CB,OG  
          TIB:VAL 230:N,CA,C,O,CB,CG1,CG2  
          TIB:THR 231:N,CA,C,O,CB,OG1,CG2  
15          TIB:ASP 234:N,CA,C,O,CB,CG,OD1,OD2  
          TIB:ILE 235:N,CA,C,O,CB,CG1,CG2,CD1  
          TIB:ILE 238:N,CA,C,O,CB,CG1,CG2,CD1  
          TIB:GLU 239:N,CA,C,O,CB,CG,CD,OE1,OE2  
          TIB:GLY 240:N,CA,C,O  
20          TIB:GLY 245:N,CA,C,O  
          TIB:LEU 269:N,CA,C,O,CB,OXT,CG,CD1,CD2  
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  actsitelemole.list  
Subset ACTSITE:  
  actsiteatom.list  
Subset ACTSITE:  
30          TIB:SER 17:N,CA,C,O,CB,OG  
          TIB:TYR 21:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
          TIB:PHE 80:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
          TIB:ARG 81:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
          TIB:GLY 82:N,CA,C,O  
35          TIB:SER 83:N,CA,C,O,CB,OG  
          TIB:ARG 84:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
          TIB:SER 85:N,CA,C,O,CB,OG  
          TIB:ILE 86:N,CA,C,O,CB,CG1,CG2,CD1  
          TIB:GLU 87:N,CA,C,O,CB,CG,CD,OE1,OE2  
40          TIB:TRP 89:N,CA,C,O,CB,CG,CD1,CD2,NE1,CE2,CE3,CZ2,CZ3,CH2  
          TIB:ILE 90:N,CA,C,O,CB,CG1,CG2,CD1  
          TIB:PHE 113:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ  
          TIB:THR 143:N,CA,C,O,CB,OG1,CG2  
          TIB:GLY 144:N,CA,C,O  
45          TIB:HIS 145:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
          TIB:SER 146:N,CA,C,O,CB,OG  
          TIB:LEU 147:N,CA,C,O,CB,CG,CD1,CD2  
          TIB:GLY 148:N,CA,C,O  
          TIB:GLY 149:N,CA,C,O  
50          TIB:ALA 150:N,CA,C,O,CB  
          TIB:LEU 151:N,CA,C,O,CB,CG,CD1,CD2  
          TIB:ALA 152:N,CA,C,O,CB  
          TIB:THR 153:N,CA,C,O,CB,OG1,CG2  
          TIB:SER 170:N,CA,C,O,CB,OG  
55          TIB:TYR 171:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
          TIB:GLY 172:N,CA,C,O  
          TIB:ALA 173:N,CA,C,O,CB

5            TIB:PRO 174:N,CA,CD,C,O,CB,CG  
 TIB:ARG 175:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 TIB:VAL 176:N,CA,C,O,CB,CG1,CG2  
 TIB:ILE 196:N,CA,C,O,CB,CG1,CG2,CD1  
 TIB:THR 197:N,CA,C,O,CB,OG1,CG2  
 TIB:HIS 198:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
 TIB:THR 199:N,CA,C,O,CB,OG1,CG2  
 TIB:ASN 200:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:ASP 201:N,CA,C,O,CB,CG,OD1,OD2  
 10          TIB:ILE 202:N,CA,C,O,CB,CG1,CG2,CD1  
 TIB:VAL 203:N,CA,C,O,CB,CG1,CG2  
 TIB:PRO 204:N,CA,CD,C,O,CB,CG  
 TIB:ARG 205:N,CA,C,O,CB,CG,CD,NE,CZ,NH1,NH2  
 TIB:LEU 206:N,CA,C,O,CB,CG,CD1,CD2  
 15          TIB:TRP  
 221:N,CA,C,O,CB,CG,CD1,CD2,NE1,CE2,CE3,CZ2,CZ3,CH2  
 TIB:ILE 222:N,CA,C,O,CB,CG1,CG2,CD1  
 TIB:THR 226:N,CA,C,O,CB,OG1,CG2  
 TIB:GLY 246:N,CA,C,O  
 20          TIB:ASN 247:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:ASN 248:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:GLN 249:N,CA,C,O,CB,CG,CD,OE1,NE2  
 TIB:ASN 251:N,CA,C,O,CB,CG,OD1,ND2  
 TIB:ILE 252:N,CA,C,O,CB,CG1,CG2,CD1  
 25          TIB:PRO 253:N,CA,CD,C,O,CB,CG  
 TIB:ASP 254:N,CA,C,O,CB,CG,OD1,OD2  
 TIB:ILE 255:N,CA,C,O,CB,CG1,CG2,CD1  
 TIB:PRO 256:N,CA,CD,C,O,CB,CG  
 TIB:ALA 257:N,CA,C,O,CB  
 30          TIB:HIS 258:N,CA,C,O,CB,CG,ND1,CD2,CE1,NE2  
 TIB:LEU 259:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:TRP  
 260:N,CA,C,O,CB,CG,CD1,CD2,NE1,CE2,CE3,CZ2,CZ3,CH2  
 TIB:TYR 261:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 35          TIB:GLY 263:N,CA,C,O  
 TIB:LEU 264:N,CA,C,O,CB,CG,CD1,CD2  
 TIB:ILE 265:N,CA,C,O,CB,CG1,CG2,CD1  
 TIB:GLY 266:N,CA,C,O  
 TIB:THR 267:N,CA,C,O,CB,OG1,CG2  
 40          Subset RESTX:  
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 45          NEWMODEL:104-106,120,136,225,227-229,250,262,268  
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 NEWMODEL:TYR 16:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ,OH  
 50          NEWMODEL:ALA 18:N,CA,C,O,CB  
 NEWMODEL:ALA 19:N,CA,C,O,CB  
 NEWMODEL:ALA 20:N,CA,C,O,CB  
 NEWMODEL:GLY 31:N,CA,C,O  
 NEWMODEL:THR 32:N,CA,C,O,CB,OG1,CG2  
 55          NEWMODEL:ASN 33:N,CA,C,O,CB,CG,OD1,ND2  
 NEWMODEL:ILE 34:N,CA,C,O,CB,CG1,CG2,CD1  
 NEWMODEL:CYS 36:N,CA,C,O,CB,SG

	NEWMODEL:GLY 38:N,CA,C,O
	NEWMODEL:ALA 40:N,CA,C,O,CB
	NEWMODEL:ASP 48:N,CA,C,O,CB,CG,OD1,OD2
	NEWMODEL:ALA 49:N,CA,C,O,CB
5	NEWMODEL:THR 50:N,CA,C,O,CB,OG1,CG2
	NEWMODEL:GLU 56:N,CA,C,O,CB,CG,CD,OE1,OE2
	NEWMODEL:ASP 57:N,CA,C,O,CB,CG,OD1,OD2
	NEWMODEL:SER 58:N,CA,C,O,CB,OG
	NEWMODEL:GLY 59:N,CA,C,O
10	NEWMODEL:VAL 60:N,CA,C,O,CB,CG1,CG2
	NEWMODEL:GLY 61:N,CA,C,O
	NEWMODEL:ASP 62:N,CA,C,O,CB,CG,OD1,OD2
	NEWMODEL:VAL 63:N,CA,C,O,CB,CG1,CG2
	NEWMODEL:THR 64:N,CA,C,O,CB,OG1,CG2
15	NEWMODEL:GLY 65:N,CA,C,O
	NEWMODEL:PHE 66:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ
	NEWMODEL:ALA 68:N,CA,C,O,CB
	NEWMODEL:LEU 78:N,CA,C,O,CB,CG,CD1,CD2
	NEWMODEL:SER 79:N,CA,C,O,CB,OG
20	NEWMODEL:ASN 88:N,CA,C,O,CB,CG,OD1,ND2
	NEWMODEL:GLY 91:N,CA,C,O
	NEWMODEL:ASN 92:N,CA,C,O,CB,CG,OD1,ND2
	NEWMODEL:LEU 93:N,CA,C,O,CB,CG,CD1,CD2
	NEWMODEL:CYS 104:N,CA,C,O,CB,SG
25	NEWMODEL:SER 105:N,CA,C,O,CB,OG
	NEWMODEL:GLY 106:N,CA,C,O
	NEWMODEL:VAL 120:N,CA,C,O,CB,CG1,CG2
	NEWMODEL:PRO 136:N,CA,CD,C,O,CB,CG
	NEWMODEL:GLY 225:N,CA,C,O
30	NEWMODEL:LEU 227:N,CA,C,O,CB,CG,CD1,CD2
	NEWMODEL:VAL 228:N,CA,C,O,CB,CG1,CG2
	NEWMODEL:PRO 229:N,CA,CD,C,O,CB,CG
	NEWMODEL:PRO 250:N,CA,CD,C,O,CB,CG
	NEWMODEL:PHE 262:N,CA,C,O,CB,CG,CD1,CD2,CE1,CE2,CZ
35	NEWMODEL:CYS 268:N,CA,C,O,CB,SG

**Example 10**

Providing a lipase variant E87K+D254K

The *Humicola lanuginosa* lipase variant E87K+D254K was  
40 constructed, expressed and purified as described in WO  
92/05249.

**Example 11**

Lipase-S-PEG 15,000 conjugate

45 The lipase variant E87K+D254K-SPEG conjugate was prepared as  
described in Example 7, except that the enzyme is the *Humicola*  
*lanuginosa* lipase variant (E87K+D254K) described in Example 10  
and the polymer is mPEG15,000.

Immunoogeneity assessed as IgG<sub>1</sub> of lipase variant (D87K+D254K) in Balb/C mice

Balb/c mice were immunized by subcutanuous injection of:

- i) 50  $\mu$ l 0.9% (wt/vol) NaCl solution (control group, 8 mice)
- 5 (control),
- ii) 50 $\mu$ l 0.9% (wt/vol) NaCl solution containing 25  $\mu$ g of protein of a *Humicola lanuginosa* lipase variant (E87K+D254K) (group 1, 8 mice) (unmodified lipase variant),
- iii) 50% 0.9% (wt/vol) NaCl solution containing a *Humicola lanugoinosa* lipase variant substituted in position D87K+D254K and coupled to a N-succinimidyl carbonate activated mPEG 15,000 (group 10, 8 mice) (lipase-SPEG15,000).

The amount of protein for each batch was measured by optical density measurements. Blood samples (200  $\mu$ l) were collected 15 from the eyes one week after the immunization, but before the following immunization. Serum was obtained by blood clothing, and centrifugation.

The IgG<sub>1</sub> response was determined by use of the Balb/C mice IgG<sub>1</sub> ELISA method as described above.

20 Results:

Five weekly immunizations were required to elicit a detectable humoral response to the unmodified *Humicola lanuginosa* variant. The antibody titers elicited by the conjugate (i.e. lipase-SPEG15,000 ranged between 960 and 1920, 25 and were only 2 to 4x lower than the antibody titer of 3840 that was elicited by unmodified HL82-Lipolase (figure to the left).

The results of the tests are shown in Figure 1

As will be apparent to those skilled in the art, in the light 30 of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

## (i) APPLICANT:

5 (A) NAME: Novo Nordisk A/S  
 (B) STREET: Novo Alle  
 (C) CITY: Bagsværd  
 (E) COUNTRY: Denmark  
 (F) POSTAL CODE (ZIP): DK-2880  
 10 (G) TELEPHONE: +45 4444 8888  
 (H) TELEFAX: +45 4449 3256

(ii) TITLE OF INVENTION: A modified polypeptide  
 (iii) NUMBER OF SEQUENCES: 9  
 (iv) COMPUTER READABLE FORM:  
 15 (A) MEDIUM TYPE: Floppy disk  
 (B) COMPUTER: IBM PC compatible  
 (C) OPERATING SYSTEM: PC-DOS/MS-DOS  
 (D) SOFTWARE: PatentIn Release #1.0, Version #1.30 (EPO)

## 20 (2) INFORMATION FOR SEQ ID NO: 1:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 840 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 25 (D) TOPOLOGY: linear  
 (ii) MOLECULE TYPE: DNA (genomic)  
 (vi) ORIGINAL SOURCE:  
 (B) STRAIN: *Bacillus* sp. PD498, NCIMB No. 40484  
 (ix) FEATURE:  
 30 (A) NAME/KEY: CDS  
 (B) LOCATION: 1..840  
 (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 1:

35	TGG TCA CCG AAT GAC CCT TAC TAT TCT GCT TAC CAG TAT GGA CCA CAA Trp Ser Pro Asn Asp Pro Tyr Tyr Ser Ala Tyr Gln Tyr Gly Pro Gln 1 5 10 15	48
40	AAC ACC TCA ACC CCT GCT GCC TGG GAT GTA ACC CGT GGA AGC AGC ACT Asn Thr Ser Thr Pro Ala Ala Trp Asp Val Thr Arg Gly Ser Ser Thr 20 25 30	96
45	CAA ACG GTG GCG GTC CTT GAT TCC GGA GTG GAT TAT AAC CAC CCT GAT Gln Thr Val Ala Val Leu Asp Ser Gly Val Asp Tyr Asn His Pro Asp 35 40 45	144
50	CTT GCA AGA AAA GTA ATA AAA GGG TAC GAC TTT ATC GAC AGG GAC AAT Leu Ala Arg Lys Val Ile Lys Gly Tyr Asp Phe Ile Asp Arg Asp Asn 50 55 60	192
55	AAC CCA ATG GAT CTT AAC GGA CAT GGT ACC CAT GTT GCC GGT ACT GTT Asn Pro Met Asp Leu Asn Gly His Gly Thr His Val Ala Gly Thr Val 65 70 75 80	240
60	GCT GCT GAT ACG AAC AAT GGA ATT GGC GTA GCC GGT ATG GCA CCA GAT Ala Ala Asp Thr Asn Asn Gly Ile Gly Val Ala Gly Met Ala Pro Asp 85 90 95	288
65	ACG AAG ATC CTT GCC GTA CGG GTC CTT GAT GCC AAT GGA AGT GGC TCA Thr Lys Ile Leu Ala Val Arg Val Leu Asp Ala Asn Gly Ser Gly Ser 100 105 110	336
70	CTT GAC AGC ATT GCC TCA GGT ATC CGC TAT GCT GAT CAA GGG GCA Leu Asp Ser Ile Ala Ser Gly Ile Arg Tyr Ala Ala Asp Gln Gly Ala 115 120 125	384
75	AAG GTA CTC AAC CTC TCC CTT GGT TGC GAA TGC AAC TCC ACA ACT CTT Lys Val Leu Asn Leu Ser Leu Gly Cys Glu Cys Asn Ser Thr Thr Leu 130 135 140	432
80	AAG AGT GCC GTC GAC TAT GCA TGG AAC AAA GGA GCT GTA GTC GTT GCT	480

145	Lys Ser Ala Val Asp Tyr Ala Trp Asn Lys Gly Ala Val Val Val Ala	150	155	160		
5	GCT GCA GGG AAT GAC AAT GTA TCC CGT ACA TTC CAA CCA GCT TCT TAC				528	
	Ala Ala Gly Asn Asp Asn Val Ser Arg Thr Phe Gln Pro Ala Ser Tyr					
	165	170	175			
10	CCT AAT GCC ATT GCA GTA GGT GCC ATT GAC TCC AAT GAT CGA AAA GCA				576	
	Pro Asn Ala Ile Ala Val Gly Ala Ile Asp Ser Asn Asp Arg Lys Ala					
	180	185	190			
	TCA TTC TCC AAT TAC GGA ACG TGG GTG GAT GTC ACT GCT CCA GGT GTG				624	
	Ser Phe Ser Asn Tyr Gly Thr Trp Val Asp Val Thr Ala Pro Gly Val					
	195	200	205			
15	AAC ATA GCA TCA ACC GTT CCG AAT AAT GGC TAC TCC TAC ATG TCT GGT				672	
	Asn Ile Ala Ser Thr Val Pro Asn Asn Gly Tyr Ser Tyr Met Ser Gly					
	210	215	220			
20	ACG TCC ATG GCA TCC CCT CAC GTG GCC GGT TTG GCT GCT TTG TTG GCA				720	
	Thr Ser Met Ala Ser Pro His Val Ala Gly Leu Ala Ala Leu Ala					
	225	230	235	240		
25	AGT CAA GGT AAG AAT AAC GTA CAA ATC CGC CAG GCC ATT GAG CAA ACC				768	
	Ser Gln Gly Lys Asn Asn Val Gln Ile Arg Gln Ala Ile Glu Gln Thr					
	245	250	255			
30	GCC GAT AAG ATC TCT GGC ACT GGA ACA AAC TTC AAG TAT GGT AAA ATC				816	
	Ala Asp Lys Ile Ser Gly Thr Asn Phe Lys Tyr Gly Lys Ile					
	260	265	270			
	AAC TCA AAC AAA GCT GTA AGA TAC				840	
	Asn Ser Asn Lys Ala Val Arg Tyr					
	275	280				
35	(2) INFORMATION FOR SEQ ID NO: 2:					
	(i) SEQUENCE CHARACTERISTICS:					
	(A) LENGTH: 280 amino acids					
40	(B) TYPE: amino acid					
	(D) TOPOLOGY: linear					
	(ii) MOLECULE TYPE: protein					
	(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 2:					

45	Trp Ser Pro Asn Asp Pro Tyr Tyr Ser Ala Tyr Gln Tyr Gly Pro Gln	1	5	10	15
	Asn Thr Ser Thr Pro Ala Ala Trp Asp Val Thr Arg Gly Ser Ser Thr	20	25	30	
50	Gln Thr Val Ala Val Leu Asp Ser Gly Val Asp Tyr Asn His Pro Asp	35	40	45	
	Leu Ala Arg Lys Val Ile Lys Gly Tyr Asp Phe Ile Asp Arg Asp Asn	50	55	60	
	Asn Pro Met Asp Leu Asn Gly His Gly Thr His Val Ala Gly Thr Val	65	70	75	80
60	Ala Ala Asp Thr Asn Asn Gly Ile Gly Val Ala Gly Met Ala Pro Asp	85	90	95	
	Thr Lys Ile Leu Ala Val Arg Val Leu Asp Ala Asn Gly Ser Gly Ser	100	105	110	
65	Leu Asp Ser Ile Ala Ser Gly Ile Arg Tyr Ala Ala Asp Gln Gly Ala	115	120	125	
	Lys Val Leu Asn Leu Ser Leu Gly Cys Glu Cys Asn Ser Thr Thr Leu	70	130	135	140

Lys Ser Ala Val Asp Tyr Ala Trp Asn Lys Gly Ala Val Val Val Ala  
 145 150 155 160

5 Ala Ala Gly Asn Asp Asn Val Ser Arg Thr Phe Gln Pro Ala Ser Tyr  
 165 170 175

Pro Asn Ala Ile Ala Val Gly Ala Ile Asp Ser Asn Asp Arg Lys Ala  
 180 185 190

10 Ser Phe Ser Asn Tyr Gly Thr Trp Val Asp Val Thr Ala Pro Gly Val  
 195 200 205

15 Asn Ile Ala Ser Thr Val Pro Asn Asn Gly Tyr Ser Tyr Met Ser Gly  
 210 215 220

Thr Ser Met Ala Ser Pro His Val Ala Gly Leu Ala Ala Leu Leu Ala  
 225 230 235 240

20 Ser Gln Gly Lys Asn Asn Val Gln Ile Arg Gln Ala Ile Glu Gln Thr  
 245 250 255

Ala Asp Lys Ile Ser Gly Thr Gly Thr Asn Phe Lys Tyr Gly Lys Ile  
 260 265 270

25 Asn Ser Asn Lys Ala Val Arg Tyr  
 275 280

30 (2) INFORMATION FOR SEQ ID NO: 3:  
 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 269 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

35 (ii) MOLECULE TYPE: protein  
 (vi) ORIGINAL SOURCE:  
 (B) STRAIN: *Bacillus lentsus*  
 (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 1:

40 Ala Gln Ser Val Pro Trp Gly Ile Ser Arg Val Gln Ala Pro Ala Ala  
 1 5 10 15

His Asn Arg Gly Leu Thr Gly Ser Gly Val Lys Val Ala Val Leu Asp  
 20 25 30

45 Thr Gly Ile Ser Thr His Pro Asp Leu Asn Ile Arg Gly Gly Ala Ser  
 35 40 45

50 Phe Val Pro Gly Glu Pro Ser Thr Gln Asp Gly Asn Gly His Gly Thr  
 50 55 60

His Val Ala Gly Thr Ile Ala Ala Leu Asn Asn Ser Ile Gly Val Leu  
 65 70 75 80

55 Gly Val Ala Pro Ser Ala Glu Leu Tyr Ala Val Lys Val Leu Gly Ala  
 85 90 95

Ser Gly Ser Gly Ser Val Ser Ser Ile Ala Gln Gly Leu Glu Trp Ala  
 100 105 110

60 Gly Asn Asn Gly Met His Val Ala Asn Leu Ser Leu Gly Ser Pro Ser  
 115 120 125

65 Pro Ser Ala Thr Leu Glu Gln Ala Val Asn Ser Ala Thr Ser Arg Gly  
 130 135 140

Val Leu Val Val Ala Ala Ser Gly Asn Ser Gly Ala Gly Ser Ile Ser  
 145 150 155 160

70 Tyr Pro Ala Arg Tyr Ala Asn Ala Met Ala Val Gly Ala Thr Asp Gln

	165	170	175
	Asn Asn Asn Arg Ala Ser Phe Ser Gln Tyr Gly Ala Gly Leu Asp Ile		
	180	185	190
5	Val Ala Pro Gly Val Asn Val Gln Ser Thr Tyr Pro Gly Ser Thr Tyr		
	195	200	205
10	Ala Ser Leu Asn Gly Thr Ser Met Ala Thr Pro His Val Ala Gly Ala		
	210	215	220
	Ala Ala Leu Val Lys Gln Lys Asn Pro Ser Trp Ser Asn Val Gln Ile		
	225	230	235
	240		
15	Arg Asn His Leu Lys Asn Thr Ala Thr Ser Leu Gly Ser Thr Asn Leu		
	245	250	255
	Tyr Gly Ser Gly Leu Val Asn Ala Glu Ala Ala Thr Arg		
	260	265	
20			
	(2) INFORMATION FOR SEQ ID NO: 4:		
	(i) SEQUENCE CHARACTERISTICS:		
	(A) LENGTH: 344 amino acids		
25	(B) TYPE: amino acid		
	(C) STRANDEDNESS: single		
	(D) TOPOLOGY: linear		
	(ii) MOLECULE TYPE: protein		
30	(vi) ORIGINAL SOURCE:		
	(B) STRAIN: Arthromyces ramosus		
	(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 1:		
	Gln Gly Pro Gly Gly Gly Ser Val Thr Cys Pro Gly Gly Gln		
	1	5	10
	15		
35	Ser Thr Ser Asn Ser Gln Cys Cys Val Trp Phe Asp Val Leu Asp Asp		
	20	25	30
	Leu Gln Thr Asn Phe Tyr Gln Gly Ser Lys Cys Glu Ser Pro Val Arg		
	35	40	45
40	Lys Ile Leu Arg Ile Val Phe His Asp Ala Ile Gly Phe Ser Pro Ala		
	50	55	60
45	Leu Thr Ala Ala Gly Gln Phe Gly Gly Gly Ala Asp Gly Ser Ile		
	65	70	75
	80		
	Ile Ala His Ser Asn Ile Glu Leu Ala Phe Pro Ala Asn Gly Gly Leu		
	85	90	95
50	Ile Asp Thr Ile Glu Ala Leu Arg Ala Val Gly Ile Asn His Gly Val		
	100	105	110
	Ser Phe Gly Asp Leu Ile Gln Phe Ala Thr Ala Val Gly Met Ser Asn		
55	115	120	125
	Cys Pro Gly Ser Pro Arg Leu Glu Phe Leu Thr Gly Arg Ser Asn Ser		
	130	135	140
60	Ser Gln Pro Ser Pro Pro Ser Leu Ile Pro Gly Pro Gly Asn Thr Val		
	145	150	155
	160		
	Thr Ala Ile Leu Asp Arg Met Gly Asp Ala Gly Phe Ser Pro Asp Glu		
	165	170	175
65	Val Val Asp Leu Leu Ala Ala His Ser Leu Ala Ser Gln Glu Gly Leu		
	180	185	190
	Asn Ser Ala Ile Phe Arg Ser Pro Leu Asp Ser Thr Pro Gln Val Phe		
	195	200	205

Asp Thr Gln Phe Tyr Ile Glu Thr Leu Leu Lys Gly Thr Thr Gln Pro  
 210 215 220  
 5 Gly Pro Ser Leu Gly Phe Ala Glu Glu Leu Ser Pro Phe Pro Gly Glu  
 225 230 235 240  
 Phe Arg Met Arg Ser Asp Ala Leu Leu Ala Arg Asp Ser Arg Thr Ala  
 245 250 255  
 10 Cys Arg Trp Gln Ser Met Thr Ser Ser Asn Glu Val Met Gly Gln Arg  
 260 265 270  
 Tyr Arg Ala Ala Met Ala Lys Met Ser Val Leu Gly Phe Asp Arg Asn  
 15 275 280 285  
 Ala Leu Thr Asp Cys Ser Asp Val Ile Pro Ser Ala Val Ser Asn Asn  
 290 295 300  
 20 Ala Ala Pro Val Ile Pro Gly Gly Leu Thr Val Asp Asp Ile Glu Val  
 305 310 315 320  
 Ser Cys Pro Ser Glu Pro Phe Pro Glu Ile Ala Thr Ala Ser Gly Pro  
 325 330 335  
 25 Leu Pro Ser Leu Ala Pro Ala Pro  
 340

## (2) INFORMATION FOR SEQ ID NO: 5:

(i) SEQUENCE CHARACTERISTICS:  
 30 (A) LENGTH: 876 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear  
 35 (iii) MOLECULE TYPE: DNA (genomic)  
 (vi) ORIGINAL SOURCE:  
 (B) STRAIN: *Humicola lanuginosa* DSM 4109  
 (ix) FEATURE:  
 (A) NAME/KEY: sig\_peptide  
 (B) LOCATION:1..66  
 40 (ix) FEATURE:  
 (A) NAME/KEY: mat\_peptide  
 (B) LOCATION:67..876  
 (ix) FEATURE:  
 (A) NAME/KEY: CDS  
 (B) LOCATION:1..876  
 45 (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 5:

ATG AGG AGC TCC CTT GTG CTG TTC TTT GTC TCT GCG TGG ACG GCC TTG	48
Met Arg Ser Ser Leu Val Leu Phe Phe Val Ser Ala Trp Thr Ala Leu	
50 -22 -20 -15 -10	
GCC AGT CCT ATT CGT CGA GAG GTC TCG CAG GAT CTG TTT AAC CAG TTC	96
Ala Ser Pro Ile Arg Arg Glu Val Ser Gln Asp Leu Phe Asn Gln Phe	
55 -5 1 5 10	
AAT CTC TTT GCA CAG TAT TCT GCA GCC GCA TAC TGC GGA AAA AAC AAT	144
Asn Leu Phe Ala Gln Tyr Ser Ala Ala Ala Tyr Cys Gly Lys Asn Asn	
60 15 20 25	
GAT GCC CCA GCT GGT ACA AAC ATT ACG TGC ACG GGA AAT GCC TGC CCC	192
Asp Ala Pro Ala Gly Thr Asn Ile Thr Cys Thr Gly Asn Ala Cys Pro	
65 30 35 40	
GAG GTA GAG AAG GCG GAT GCA ACG TTT CTC TAC TCG TTT GAA GAC TCT	240
65 Glu Val Glu Lys Ala Asp Ala Thr Phe Leu Tyr Ser Phe Glu Asp Ser	
45 50 55	
GGA GTG GGC GAT GTC ACC GGC TTC CTT GCT CTC GAC AAC ACG AAC AAA	288
Gly Val Gly Asp Val Thr Gly Phe Leu Ala Leu Asp Asn Thr Asn Lys	
70 60 65 70	

TTG ATC GTC CTC TCT TTC CGT GGC TCT CGT TCC ATA GAG AAC TGG ATC Leu Ile Val Leu Ser Phe Arg Gly Ser Arg Ser Ile Glu Asn Trp Ile 75 80 85 90	336
5 GGG AAT CTT AAC TTC GAC TTG AAA GAA ATA AAT GAC ATT TGC TCC GGC Gly Asn Leu Asn Phe Asp Leu Lys Glu Ile Asn Asp Ile Cys Ser Gly 95 100 105	384
10 TGC AGG GGA CAT GAC GGC TTC ACT TCG TCC TGG AGG TCT GTA GCC GAT Cys Arg Gly His Asp Gly Phe Thr Ser Ser Trp Arg Ser Val Ala Asp 110 115 120	432
15 ACG TTA AGG CAG AAG GTG GAG GAT GCT GTG AGG GAG CAT CCC GAC TAT Thr Leu Arg Gln Lys Val Glu Asp Ala Val Arg Glu His Pro Asp Tyr 125 130 135	480
20 CGC GTG GTG TTT ACC GGA CAT AGC TTG GGT GCA TTG GCA ACT GTT Arg Val Val Phe Thr Gly His Ser Leu Gly Gly Ala Leu Ala Thr Val 140 145 150	528
25 GCC GGA GCA GAC CTG CGT GGA AAT GGG TAT GAT ATC GAC GTG TTT TCA Ala Gly Ala Asp Leu Arg Gly Asn Gly Tyr Asp Ile Asp Val Phe Ser 155 160 165 170	576
30 TAT GGC GCC CCC CGA GTC GGA AAC AGG GCT TTT GCA GAA TTC CTG ACC Tyr Gly Ala Pro Arg Val Gly Asn Arg Ala Phe Ala Glu Phe Leu Thr 175 180 185	624
35 GTA CAG ACC GGC GGA ACA CTC TAC CGC ATT ACC CAC ACC AAT GAT ATT Val Gln Thr Gly Thr Leu Tyr Arg Ile Thr His Thr Asn Asp Ile 190 195 200	672
40 GTC CCT AGA CTC CCG CCG CGC GAA TTC GGT TAC AGC CAT TCT AGC CCA Val Pro Arg Leu Pro Pro Arg Glu Phe Gly Tyr Ser His Ser Ser Pro 205 210 215	720
45 GAG TAC TGG ATC AAA TCT GGA ACC CTT GTC CCC GTC ACC CGA AAC GAT Glu Tyr Trp Ile Lys Ser Gly Thr Leu Val Pro Val Thr Arg Asn Asp 220 225 230	768
50 ATC GTG AAG ATA GAA GGC ATC GAT GCC ACC GGC GGC AAT AAC CAG CCT Ile Val Lys Ile Glu Gly Ile Asp Ala Thr Gly Gly Asn Asn Gln Pro 235 240 245 250	816
55 AAC ATT CCG GAT ATC CCT GCG CAC CTA TGG TAC TTC GGG TTA ATT GGG Asn Ile Pro Asp Ile Pro Ala His Leu Trp Tyr Phe Gly Leu Ile Gly 255 260 265	864
60 50 ACA TGT CTT TAG Thr Cys Leu * 270	876
(2) INFORMATION FOR SEQ ID NO: 6:	
55 (i) SEQUENCE CHARACTERISTICS:	
(A) LENGTH: 292 amino acids	
(B) TYPE: amino acid	
(D) TOPOLOGY: linear	
60 (iii) MOLECULE TYPE: protein	
60 (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 2:	
Met Arg Ser Ser Leu Val Leu Phe Phe Val Ser Ala Trp Thr Ala Leu -22 -20 -15 -10	
65 Ala Ser Pro Ile Arg Arg Glu Val Ser Gln Asp Leu Phe Asn Gln Phe -5 1 5 10	
Asn Leu Phe Ala Gln Tyr Ser Ala Ala Tyr Cys Gly Lys Asn Asn 15 20 25	

Asp Ala Pro Ala Gly Thr Asn Ile Thr Cys Thr Gly Asn Ala Cys Pro  
 30 35 40  
 Glu Val Glu Lys Ala Asp Ala Thr Phe Leu Tyr Ser Phe Glu Asp Ser  
 5 45 50 55  
 Gly Val Gly Asp Val Thr Gly Phe Leu Ala Leu Asp Asn Thr Asn Lys  
 60 65 70  
 10 Leu Ile Val Leu Ser Phe Arg Gly Ser Arg Ser Ile Glu Asn Trp Ile  
 75 80 85 90  
 Gly Asn Leu Asn Phe Asp Leu Lys Glu Ile Asn Asp Ile Cys Ser Gly  
 95 100 105  
 15 Cys Arg Gly His Asp Gly Phe Thr Ser Ser Trp Arg Ser Val Ala Asp  
 110 115 120  
 Thr Leu Arg Gln Lys Val Glu Asp Ala Val Arg Glu His Pro Asp Tyr  
 20 125 130 135  
 Arg Val Val Phe Thr Gly His Ser Leu Gly Gly Ala Leu Ala Thr Val  
 140 145 150  
 25 Ala Gly Ala Asp Leu Arg Gly Asn Gly Tyr Asp Ile Asp Val Phe Ser  
 155 160 165 170  
 Tyr Gly Ala Pro Arg Val Gly Asn Arg Ala Phe Ala Glu Phe Leu Thr  
 175 180 185  
 30 Val Gln Thr Gly Gly Thr Leu Tyr Arg Ile Thr His Thr Asn Asp Ile  
 190 195 200  
 Val Pro Arg Leu Pro Pro Arg Glu Phe Gly Tyr Ser His Ser Ser Pro  
 35 205 210 215  
 Glu Tyr Trp Ile Lys Ser Gly Thr Leu Val Pro Val Thr Arg Asn Asp  
 220 225 230  
 40 Ile Val Lys Ile Glu Gly Ile Asp Ala Thr Gly Gly Asn Asn Gln Pro  
 235 240 245 250  
 Asn Ile Pro Asp Ile Pro Ala His Leu Trp Tyr Phe Gly Leu Ile Gly  
 255 260 265  
 45 Thr Cys Leu \*  
 270

## 50 (2) INFORMATION FOR SEQ ID NO: 7:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 32 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

55 (ii) MOLECULE TYPE: other nucleic acid  
 (A) DESCRIPTION: /desc = "R28K oligo"  
 (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 7:

60 gggatgtaac caagggaagc agcactcaaa cg

32

## (2) INFORMATION FOR SEQ ID NO: 8:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 27 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single

65

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: other nucleic acid

(A) DESCRIPTION: /desc = "R62K oligo"

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 8:

5 cgactttatc gataaggaca ataaccc

27

(2) INFORMATION FOR SEQ ID NO: 9:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 27 base pairs

10 (B) TYPE: nucleic acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: other nucleic acid

(A) DESCRIPTION: /desc = "R169K oligo"

15 (xi) SEQUENCE DESCRIPTION: SEQ ID NO: 9:

caatgtatcc aaaacgttcc aaccagc

27

## Patent Claims

1. A polypeptide-polymer conjugate having
  - a) one or more additional polymeric molecules coupled to the polypeptide, having been modified in a manner to increase the number of attachment groups on the surface of the polypeptide, in comparison to the number of attachment groups available on the corresponding parent polypeptide, and/or
  - b) one or more fewer polymeric molecules coupled to the polypeptide, having been modified in a manner to decrease the number of attachment groups at or close to the functional site(s) of the polypeptide, in comparison to the number of attachment groups available on the corresponding parent polypeptide.
2. The conjugate according to claims 1, having 1 to 25, preferably 1 to 10 additional polymeric molecules coupled to the surface of the polypeptide in comparison to the number of polymeric molecules of a conjugate prepared from the corresponding parent enzyme.
3. The conjugate according to claims 1 and 2, wherein the additional attachment group(s) is(are) amino groups in the form of Lysine residues(s), or carboxylic groups in the form of Aspartic acid or Glutamic acid residues.
4. The conjugate according to any of claims 1 to 3, wherein the additional attachment group(s) is(are) prepared by a conservative substitution of an amino acid residue, such as an Arginine to Lysine substitution.
5. The conjugate according to claims 1 to 3, wherein the additional attachment group(s) is(are) prepared by a conservative substitution of an amino acid, such as an Asparagine to Aspartate/Glutamate or a Glutamine to Aspartate/Glutamate substitution.
6. The conjugate according to any of claims 1 to 5, wherein the added attachment group is located more than 5 Å, preferably 8 Å, especially 10 Å from the functional site.
- 35 7. The conjugate according to claim 1, having 1 to 25 preferably 1 to 10 fewer polymeric molecules coupled at or close to the functional site of the polypeptide in comparison to the number of polymeric molecules of a conjugate prepared on the basis of the corresponding parent polypeptide.

8. The conjugate according to claim 7, wherein the removed attachment group(s) is(are) amino groups in the form of Lysine residues(s), or carboxylic groups in the form of Aspartic acid or Glutamic acid residues.

5 9. The conjugate according to any of claims 7 and 8, wherein the removed attachment group(s) is(are) prepared by a conservative substitution of an amino group, such as Lysine to Arginine substitution.

10. The conjugate according to any of claims 7 to 8, wherein the removed attachment group(s) is(are) prepared by a conservative substitution of a carboxylic group, such as an Aspartate/Glutamate to Aspargine or Aspartate/Glutamate to a Glutamine substitution.

11. The conjugate according to any of claims 1 to 10, wherein the removed attachment group is located within 5 Å, preferably 8 Å, especially 10 Å from the functional site.

12. The conjugate according to any of claims 1 to 11, wherein the attachment groups are broadly spread.

13. The conjugates according to claims 1 to 12, wherein the parent polypeptide moiety of the conjugate has a molecular weight from 1 to 100 kDa, preferred 15 to 100 kDa.

14. The conjugate according to claim 13, wherein the parent polypeptide moiety of the conjugate has a molecular weight of from 1 to 35 kDa.

15. The conjugates according to claim 14, wherein the parent polypeptide is an enzyme selected from the group of Oxidoreductases, including laccases and Superoxide dismutase (SOD); Hydrolases, including proteases, especially subtilisins, and lipolytic enzymes; Transferases, including Transglutaminases (TGases); Isomerases, including Protein disulfide Isomerases (PDI).

16. The conjugate according to claim 15, wherein the parent enzyme is PD498, Savinase®, BPN', Proteinase K, Proteinase R, Subtilisin DY, Lion Y, Rennilase®, JA16, Alcalase® or a *Humicola lanuginosa* lipase, such as Lipolase®.

35 17. The conjugate according to claim 16, wherein the enzyme moiety of the conjugate is a PD498 variant with one or more of the following substitutions: R51K, R62K, R121K, R169K, R250K, R28K, R190K, P6K, Y7K, S9K, A10K, Y11K, Q12K, D43K, Y44K, N45K, N65K,

G87K, I88K, N209K, A211K, N216K, N217K, G218K, Y219K, S220K, Y221K, G262K.

18. The conjugate according to claim 17, with one of the following mutations: R28K+R62K, R28K+R169K, R62K + R169K,  
5 R28K+R69K+R169K.

19. The conjugate according to claim 16, wherein the enzyme moiety of the conjugate is a Savinase® variant with one or more of the following substitutions: R10K, R19K, R45K, R145K, R170K, R186K, R247K, K94R, P5K, P14K, T22K, T38K, H39K, P40K, L42K, 10 L75K, N76K, L82K, P86K, S103K, V104K, S105K, A108K, A133K, T134K, L135K, Q137K, N140K, N173K, N204K, Q206K, G211K, S212K, T213K, A215K, S216K, N269K.

20. The conjugate according to claim 16, wherein the enzyme moiety of the conjugate is a *Humicola lanuginosa* lipase variant 15 with one or more of the following substitutions:

R133K, R139K, R160K, R179K, R209K, R118K, R125K, A18K, G31K, T32K, N33K, G38K, A40K, D48K, T50K, E56K, D57K, S58K, G59K, V60K, G61K, D62K, T64K, L78K, E87K, N88K, G91K, N92K, L93K, S105K, G106K, V120K, P136K, G225 K, L227K, V228K, P229K, P250K, D254K, F262K.

20 21. The conjugate according to claim 20 with the following mutations E87K+D254K.

22. The conjugate according to any of claims 1 to 21, wherein the polymeric molecules coupled to the polypeptide have a molecular weight from 1 to 60 kDa, especially 1-35 kDa, especially 25 3 to 25 kDa.

23. The conjugate according to claim 22, wherein the polymeric molecule is selected from the group comprising a natural or synthetic homo- and heteropolymers, selected from the group of the synthetic polymeric molecules including Branched PEGs, poly-vinyl 30 alcohol (PVA), poly-carboxyl acids, poly-(vinylpyrrolidone) and poly-D,L-amino acids, or natural occurring polymeric molecules including dextrans, including carboxymethyl-dextrans, and celluloses such as methylcellulose, carboxymethylcellulose, ethylcellulose, hydroxyethylcellulose, hydroxypropylcellulose, and 35 hydrolysates of chitosan, starches, such as hydroxyethyl-starches, hydroxypropyl-starches, glycogen, agarose, guar gum, inulin, pullulans, xanthan gums, carrageenin, pectin and alginic acid.

24. A method for preparing improved polypeptide-polymer

conjugates comprising the steps of:

- a) identifying amino acid residues located on the surface of the 3D structure of the parent polypeptide in question,
- b) selecting target amino acid residues on the surface of said 3D structure of said parent polypeptide to be mutated,
- 5 c)i) substituting or inserting one or more amino acid residues selected in step b) with an amino acid residue having a suitable attachment group, and/or
- ii) substituting or deleting one or more amino acid residues 10 selected in step b) at or close to the functional site,
- d) coupling polymeric molecules to the mutated polypeptide.

25. The method according to claim 24, wherein the identification of amino acid residues located on the surface on the polypeptide referred to in step a) are performed by a computer 15 program analyzing the 3D structure of the parent polypeptide in question.

26. The method according to claim 24, wherein step b) comprises selecting Arginine or Lysine residues on the surface of the parent polypeptide.

20 27. The method according to claim 24, wherein one or more Arginine residues identified in step b) is(are) substituted with a Lysine residue(s) in step c).

28. The method according to claims 27, wherein the substituted Arginine residues have a distance of more than 5 Å, 25 preferably 8 Å, especially 10 Å from the functional site.

29. The method according to any of claims 24 to 28, wherein the polypeptide prepared in step c) is coupled to polymeric molecules.

30. Use of the conjugate in claims 1 to 23 for reducing the 30 allergenicity of industrial products.

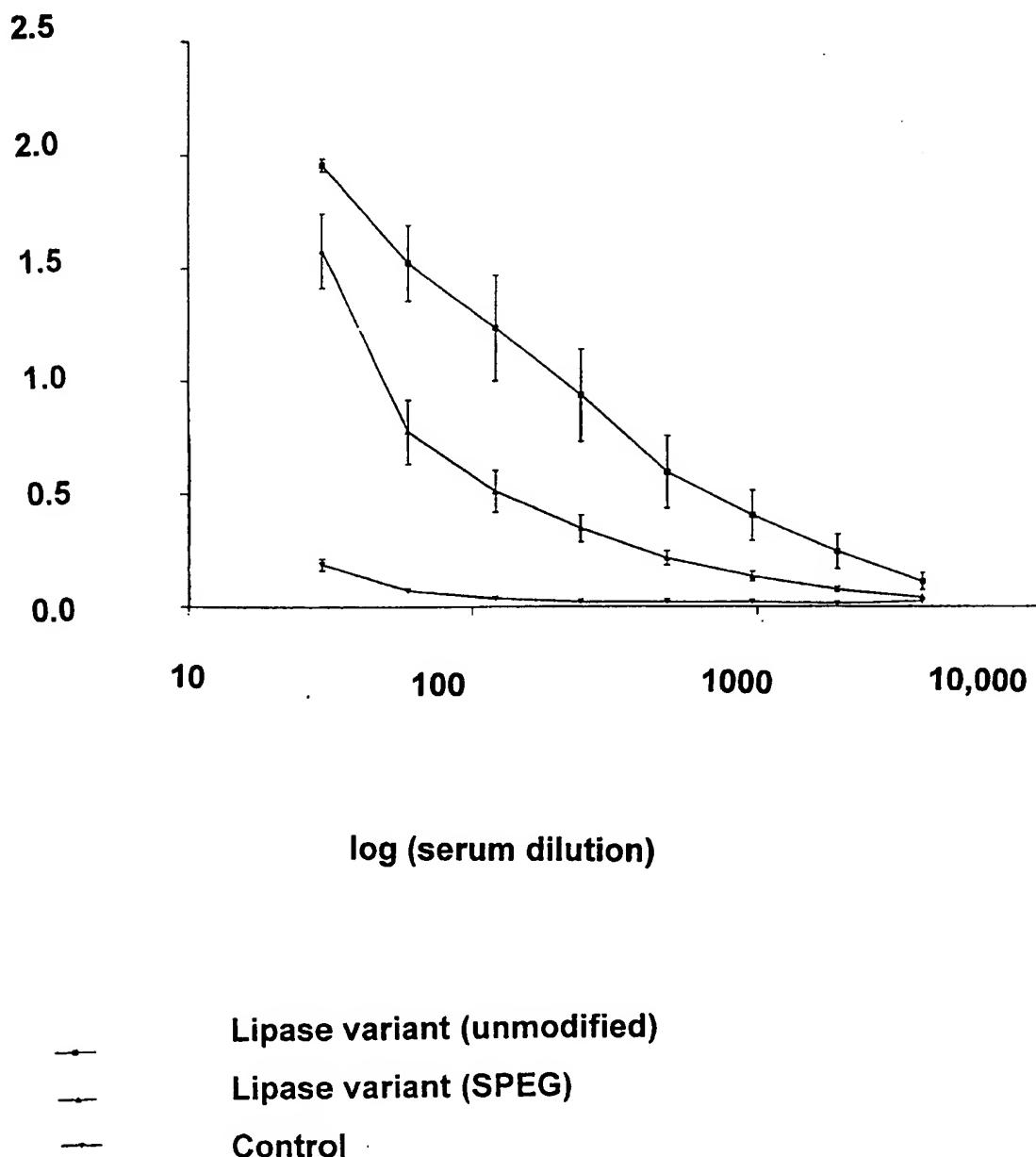
31. Use of the conjugate in claims 1 to 23 for reducing the immunogenicity of pharmaceuticals.

32. A composition comprising a conjugate of any of claims 1 to 23 and further comprising ingredients used in industrial 35 products.

33. The composition according to claim 32, wherein the industrial product is a detergent, such as a laundry, dish wash or hard surface cleaning product, or a food or feed product.

34. The composition according to claim 32, comprising a conjugate of any of claims 1 to 22 and further ingredients used in skin care products.

35. A composition comprising a conjugate of any of claims 1 to 23 and further comprising ingredients used in pharmaceuticals.

**Optical Density (490/620)****Fig. 1**

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 98/00046

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C12N 9/96, C11D 3/386, A61K 47/48

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C12N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, US PATENTS FULLTEXT, CA, MEDLINE, BIOSIS, EMBASE, DBA, SCISEARCH

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Proc. Natl. Acad. Sci., Volume 88, August 1991, Michael S. Hershfield et al, "Use of site-directed mutagenesis to enhance the epitope-shielding effect of covalent modification of proteins with polyethylene glycol" page 7185 - page 7189	1-6,12-35
A	--	7-11
X	Advanced Drug Delivery Reviews, Volume 16, 1995, Samuel Zalipsky, "Chemistry of polyethylene glycol conjugates with biologically active molecules", page 157 - page 182, see page 167-168	1-6,12-35
A	--	7-11

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier document but published on or after the international filing date	"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

25 May 1998

Date of mailing of the international search report

28-05-1998

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 98/00046

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9315189 A1 (CONSIGLIO NAZIONALE DELLE RICERCHE), 5 August 1993 (05.08.93), see page 1, lines 1-3; page 2, lines 10-30; page 3, lines 5-14  --	1,7-35
A	WO 9210755 A1 (NOVO NORDISK A/S), 25 June 1992 (25.06.92)  --	1-35
A	WO 9617929 A1 (NOVO NORDISK A/S), 13 June 1996 (13.06.96)  -----	1-35

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/DK 98/00046

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

See next sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**  

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/DK 98/00046

As is stated in Annex B to Administrative Instructions under the PCT, in force July 1, 1992 (PCT GAZETTE 1992, June 25, pages 7062-9, see page 7063 and example 5) unity of invention exists only when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding "special technical features" - i.e. features that define a contribution which each of the inventions makes over the prior art. (c.f. PCT Rule 13.2)

A search for this "special technical feature" mentioned in PCT Rule 13.2 among the independent claims did not reveal such a unifying, novel technical feature. Accordingly, the following inventions were found:

1. Claims 1(partly), 2-6, 12-35(partly) concerns a polypeptide-polymer conjugate having one or more additional polymeric molecules coupled to the polypeptide, having been modified to increase the number of attachment groups on the surface of the polypeptide.
2. Claims 1(partly), 7-11, 12-35(partly) concerns a polypeptide-polymer conjugate having one or more fewer polymeric molecules coupled to the polypeptide, having been modified to decrease the number of attachment groups at or close to the functional site(s) of the polypeptide.

The international search covers both inventions.

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

29/04/98

International application No.  
PCT/DK 98/00046

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